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The undersigned hereby certify that they have read, and recommend to the Committee on Graduate Studies for acceptance a dissertation on "The Geology of Fraser Valley, Lytton to Lillooet, B.C.", submitted by Charles Eric Bruce Conybeare, B.Sc., in partial fulfillment of the requirements for the degree of Master of Science.

THE GEOLOGY OF FRASER VALLEY, LYTTON TO LILLOOET, B.C.

by

Charles Eric Bruce Conybeare, B.Sc.,
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A Thesis
Submitted to the University of Alberta
in partial fulfillment of the
requirements for the degree
of
MASTER OF SCIENCE

Edmonton, Alberta
April 1947

THE GEOLOGY OF FRASER VALLEY

LYTTON TO LILLOOET, B.C.

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ABSTRACT

The area discussed in this thesis lies approximately 100 miles north-east of Vancouver, B.C., and constitutes the western part of the Ashcroft Sheet (Map 408A) which is bounded on the south and north by the 50th and 51st Parallels respectively, and on the west by longitude 122 degrees. The Ashcroft Sheet comprises an area along the western fringe of the Interior Plateau, and the eastern flank of the Coast Range. Lytton is situated at the confluence of Fraser River and Thompson River; Lillooet is situated some five miles south of the confluence of Fraser River and Bridge River. The elevation of Fraser Valley is approximately 1000 feet above sea level. To the east, the hills of the Interior Plateau rise to more than 5000 feet; while to the west, the Coast Mountains rise to over 9000 feet. The area is sparcely populated and has no known important mineral deposits.

The thesis is divided into three parts: geography of the area, geology of the area, and the geology of the Lillooet area. The stratigraphy, structure, and lithology of Fountain Ridge, lying immediately to the east of Lillooet, are discussed in detail.

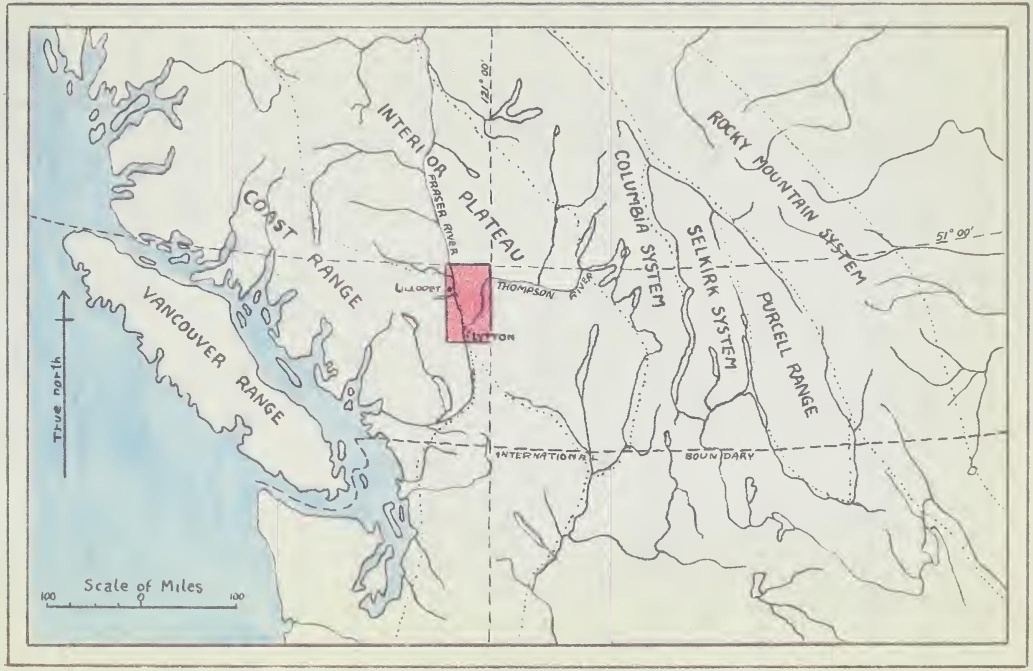
Along Fraser Valley, from south of Lytton to north of Lillooet, there extends a belt of Lower Cretaceous rocks, probably over 7000 feet thick, consisting of massive beds of argillite, arkose, graywacke, conglomerate, and some tuff. This belt consists of fault blocks, which appear to form a graben south of Lytton, and a step-faulted block at Fountain Ridge. The beds are generally steeply folded; and at Fountain Ridge they form a synclinal structure. The writer considers these beds to have been derived from the erosion of igneous and volcanic rocks which formed a height of land to the west.

Fraser Valley, as far north as Lillooet, is flanked by intrusive masses of granodiorite, which on the west form part of the Coast Mountains, and on the east, the northward extension of the Cascade Mountains. These igneous rocks intrude several thousand feet of schist, phyllite, and intercalated volcanics which the writer has tentatively correlated with the Chilliwack Group, and which are probably of Permian or Pennsylvanian age. Similar igneous rocks intrude the Lower Cretaceous sedimentary rocks. Several periods of intrusion are apparent; but what age relationships these have to the age of the Coast Range igneous bodies the writer does not know.

To the east of Fountain Ridge lies the western fringe of the Interior Plateau. The rocks here form some 2000 or more feet of volcanics, and presumably are a correlative of the Spence Bridge Volcanic Group, considered to be of Lower Cretaceous age. It is probably that part of this area consists of Tertiary volcanics. The writer considers these volcanics to overlie the Lower Cretaceous sedimentary rocks of Fountain Ridge.

Fraser Valley is filled with fluvio-glacial deposits of sand and gravel. Glacial striae on the hilltops indicate a general south-easterly movement of the Pleistocene ice sheet.

PLATE 1



LOCATION OF ASHCROFT SHEET (MAP 408 A)

INTRODUCTION

PURPOSE OF INVESTIGATION

The purport of this thesis is the compilation of a geological report on the areas flanking the western and eastern slopes of Fraser Valley, British Columbia, from Lytton northward to Pavilion, and on the area flanking the eastern slope of Fraser Valley from Lytton southward to Keefers. The specific problem concerns the structure, stratigraphy, and lithology of Fountain Ridge, east of Lillooet, from the mouth of Cinqfoil Creek at its southern extremity to the Camelsfoot Mountains extending northward from the mouth of Bridge River.

The locations investigated are referable to the Ashcroft Sheet (Map 408A). For the purpose of correlating strata mapped on this sheet, the regional stratigraphy of the adjacent Nicola, Hope and Princeton Sheets is discussed.

METHODS OF INVESTIGATION

Field Work

During the field season of 1946 the writer

was engaged as Junior Geologist by the Geological Survey of Canada to assist Mr. K. C. McTaggart in completing the mapping of the western portion of the Ashcroft Sheet. Mr. McTaggart was under the direction of Dr. S. Duffell whose party was completing the mapping of the eastern portion of the Ashcroft Sheet.

Particular attention was paid to the Lower Cretaceous sedimentary strata along Fraser Valley. For this reason, traverses across these beds were more closely spaced than those across areas of volcanics and igneous intrusives. Because mapping was done on the scale of four miles to the inch, the nature of the work precluded any detailed studies of structure or stratigraphy. However, in the case of Fountain Ridge an attempt was made to ascertain the structural and stratigraphical relationships in some detail.

The method of mapping was by means of pace and compass, positions being plotted on the Ashcroft Sheet (contour interval of 500'). To assist in pacing a counter was used. Considerable difficulty was experienced in estimating distances traversed while climbing through bush. Wherever

possible, stations were located by means of triangulation, sightings being taken with a Brunton compass on two or more known landmarks. Aneroid barometers were also used, corrections being made prior to leaving camp in the morning, and on return in the evening. However, as the contour intervals were often found to be inaccurate, barometer readings were not particularly useful as a means of determining one's position.

Rock specimens were collected of all types encountered. Directions of glacial striae, attitudes of sedimentary beds and of gneissosity in intrusives were noted. Particular care, in the case of sedimentary beds, was taken to observe 'tops' by means of crossbedding or gradation in grain size.

Laboratory Work

The laboratory work consisted of an examination of thin sections and crushed mounts of rocks from Fountain Ridge and the Lower Cretaceous volcanics to the east of Lillooet.

The samples so examined were from scattered localities; and while they did not give a detailed section in any one locality, they presented an overall

picture of the nature of the rocks in the area of Fountain Ridge.

ACKNOWLEDGEMENTS

The writer would like to express his thanks to Dr. J. A. Allan for very helpful suggestions as to the organization of this thesis; to Dr. R. L. Rutherford for guiding the writer's petrographic analyses; to Dr. P. S. Warren for his advice on stratigraphic correlations; and especially to Dr. R. E. Folinsbee for the many hours he has spent, and for the advice and help which he has so freely given.

GENERAL VIEW

OF

STEIN MOUNTAIN

PLATE 2

View from Botanie Mountain looking in a south-westerly direction across Fraser Valley toward Stein Mountain in the Coast Range.

PART 1

GEOGRAPHY OF THE AREA

PHYSICAL GEOGRAPHY

RELIEF AND ELEVATIONS

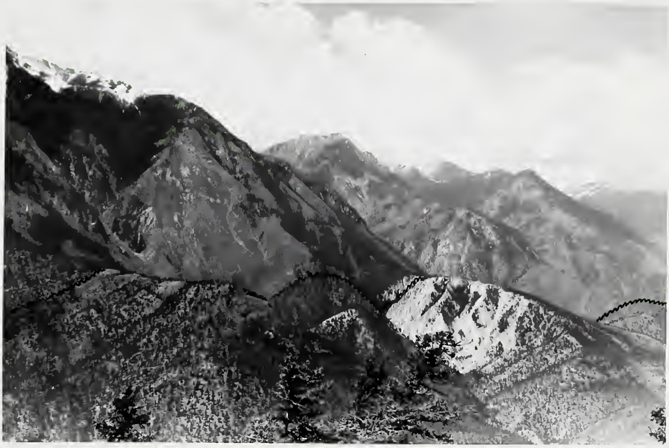
The south-western portion of the Ashcroft Sheet comprises a section of the Coast Mountains, bounded on the east by the Fraser River. On the eastern side of Fraser River, south of Lytton, the Cascade Mountains extend south-ward to Hope. On the Ashcroft Sheet the Coast Mountains are particularly rugged, rising on the average well over 7500 feet above sea level, with some peaks exceeding a height of 9000 feet.

The relief of this region undergoes a marked change east of the Fraser River and north of the Thompson River. Here lies part of the western portion of the Interior Plateau, characterized by flat topped hills around 5000 feet in height. The area is deeply incised with valleys 2000 to 3000 feet deep.

In the north-western corner of the Ashcroft Sheet, between Bridge River and Fraser River lie the Camelsfoot Mountains, rising to a height of not more than 6000 feet. These mountains are gently rolling, though presenting a steep slope from Bridge River valley.

GENERAL VIEW OF
THE COAST MOUNTAINS

PLATE 3



View from the west slope of Botanie Mountain, looking north-west across Fraser Valley toward the Coast Mountains.

The mountains in this view are largely of granodiorite,with patches of Permian? phyllite and schist,and Lower Cretaceous argillite and arkose.

In the foreground,in faulted contact with the granodiorite,are highly folded Lower Cretaceous beds of argillite and arkose. The shear zone is indicated.

In general, the western part of the Ashcroft Sheet is extremely rugged and difficult to traverse. The water level of the Fraser River at Lillooet is approximately 800 feet above sea level.

DRAINAGE

The area of the Ashcroft Sheet is drained primarily by the Fraser and Thompson Rivers. The confluence of these two rivers is at Lytton. Into the Thompson River, just above Spences Bridge flows the Nicola River. Similarly, Bridge River joins the Fraser River about five miles north of Lillooet. Into these rivers flow numerous creeks.

The drainage pattern, as a whole, is dendritic. During the spring run-off creek beds, which during mid-summer afford a mere trickle of water, become rushing torrents, piling up alluvial fans where their gradient becomes less steep as they enter the Fraser and Thompson Valleys. The writer observed several instances of levees, ten or more feet high separated by narrow gulches fifteen to twenty feet deep, down which the spring run-off water must have poured as though through a giant hydraulic sluice. The erosional power of the stream system is very great.

During the spring flood the Fraser River becomes greatly swollen, rising six or more feet above its mid-summer level. At this time the river bars become completely re-sorted; and although the large bars remain from year to year in the same general positions, they shift somewhat and continually change their shapes. The Fraser River is always muddy, unlike the Thompson River which becomes quite clear in late summer. The amount of fine grained and colloidal material carried down the Fraser River each year, and deposited on its delta, must be very great. Johnston (1921) states that the maximum load carried by flood waters of the Fraser River amounts in weight to 230 parts per million, whereas at low water the load may be as low as 10 parts per million. This fine grained material affords a curious phenomenon, causing the river to 'sing'. When standing on the bank a soft, hissing sound is continously heard. Although the writer has found no reference to this phenomenon, he is of the opinion that it is due to the corrasion of the multitude of tiny grains of material being swirled along in the current.

On the Ashcroft Sheet the Fraser, Thompson and Bridge Rivers flow generally in a south-ward

direction. Nicola River, in the south-eastern portion of the sheet, flows to the north-west. The drainage from the Coast Mountains, where snow remains above an altitude of 6000 feet until late summer, is generally toward the Fraser River to the east.

A notable anomaly to the drainage pattern is caused by a trough-like depression of the Interior Plateau between the Fraser and Thompson Rivers. The drainage into this trough is effected by Hat Creek, which flows northward. In the vicinity of the Trachyte Hills this creek divides. One branch flows to the north-west into Pavilion Lake, which is drained by Pavilion Creek into the Fraser River. The other branch flows to the north-east into Bonapart River, a creek which flows from the north, past the village of Cache Creek, emptying into the Thompson River at Ashcroft.

CLIMATE

The climate in the Ashcroft, Lytton and Lillooet area is generally temperate and dry. Annual and diurnal temperatures vary considerably. During mid-winter the mean monthly temperature is probably seldom lower than ten degrees of frost. In mid-summer the temperature on hot days often rises well over

ninety degrees Fahrenheit in the shade. As is to be expected in a dry climate, the diurnal temperature range is considerable. In mid-summer the mean lowest temperature is probably around forty degrees Fahrenheit.

Temperature ranges vary with altitude. In mid-summer, at an altitude of four to six thousand feet the mid-day temperature is pleasantly warm; while the night temperature is unpleasantly cold, falling to around forty degrees Fahrenheit. Conversely, at altitudes of less than 1000 feet in the Fraser Valley the mid-day temperatures are often very hot, rising as stated above, to around ninety degrees Fahrenheit; while the night temperatures are pleasantly cool. With some anomalies, it is probable that the vertical temperature gradient falls one degree Fahrenheit for every 300 feet rise in altitude. Detailed information on temperature ranges is given by Dawson (1894) in an appendix to his report.

Rainfall throughout the year is scanty. Dawson (1894) states that the annual rainfall at Spences Bridge is around ten inches. Even in that part of the Coast Mountains included on the Ashcroft Sheet the annual precipitation is small compared to that of the more westerly mountains in the coast ranges.

The prevailing westerly winds, by the time they arrive in the area of the Ashcroft Sheet are comparatively dry.

In the Fraser Valley the prevailing wind is from the north, probably being a subsidiary air current of the westerly winds. The writer has observed, his observation being confirmed by local inhabitants, that this prevailing northerly wind is usually accompanied by clear, dry weather; whereas when the wind does on occasion come from the south, it brings rain.

Local variations are found in the amount of precipitation. In Botanie Creek valley, just north of Lytton, the annual precipitation is unusually high. According to Dawson (1894) the snow lies to a depth of three or more feet during mid-winter. This large precipitation is no doubt the reason why such a luxuriant and varied growth of vegetation is found. At certain times of the year the Indians frequented this valley in their search for herbs and roots. It is of interest to note that the Indian word 'botanie' means 'root gathering place'.

FAUNA AND FLORA

The fauna in this region generally frequent certain horizons peculiar to their species. Although overlapping of these horizons does occur it can be said, for example, that the grizzly bear (Ursus horribilis) which is commonly found in this region, makes its habitat above 5000 feet; while the coyote (Canis latrans) which is often seen in the sage-brush covered flats of the Fraser Valley, is seldom to be found above 5000 feet.

The black tailed deer (Cariacus macrotis) is very abundant, being found at all altitudes up to timberline. The white tailed deer (Cariacus virginianis) is not so common, and usually frequents the heavily forested areas in the valleys. The black bear (Ursus americanus) is very common, usually being found above 2000 feet to timberline. Mountain goats (Oreamnos americanus) were observed by the writer, surprisingly enough, at altitudes as low as 1500 feet on granite cliffs just south of Texas Creek in the Fraser Valley. Although no moose (Alces gigas) were seen, it is evident from the prolificity of their stools that they have as wide a range as the black tailed deer. In the sage-brush covered areas, especially on rocky slopes, rattlesnakes are sometimes encountered.

A ------ View, at elevation of 1,500 feet, looking in a north-westerly direction from Botanie Mountain across Fraser Valley. Note the rocky, arid slopes of Fraser Valley, sparcely wooded with black spruce. Also note the lodge pole pine in the left foreground, and the poplar in the right foreground.

B ------ Fraser River, near Lillooet, showing the calcium carbonate encrusted high water line along the shore. The river at this point is about 300 feet wide. Note the ferry cable.

PLATE 4

A

B

Of the trees found in this region the yellow pine (Pinus ponderosa) is particularly noticeable, being found in stands at elevations usually of 1000 to 2000 feet. The white pine (Pinus albicaulis) and the jack pine (Pinus contorta) occur singly or in small stands, usually at higher altitudes of 3000 to 5000 feet. Lodge pole pine (Pinus murrayana) is particularly common at lower altitudes along the Fraser Valley. Of the spruces, the black spruce (Picea mariana) is most common. White spruce (Picea canadensis) and Sitka spruce (Picea sitchensis) are also found, the latter growing to a considerable size in small stands in well watered valleys above 1000 feet. Among the firs, balsam fir (Abies subalpina) is the commonest. The white fir (Abies grandis) grows well in moist areas above 1000 feet. The Douglas fir (Pseudotsuga douglasii) is not so common. The western larch (Larix occidentalis) is sometimes seen.

In the Fraser Valley the poplar (Populus tremuloides) is very common along the lower reaches of the numerous streams. In the same locale the Saskatoon bush (Amelanchior florida) grows abundantly. In similar moist places along streams, but at higher altitudes the devil's club (Oplopanax horridum) grows in

thick clumps. This spiny plant is most unpleasant to encounter.

CULTURAL GEOGRAPHY

ROADS AND FERRIES

On the Ashcroft Sheet the main highway between Vancouver and Kamloops follows the Fraser River on the east side to Lytton, thence continuing along the Thompson River on the south side to Spences Bridge. Here the highway crosses the Thompson River, temporarily leaving the river valley to pass through the village of Cache Creek. This highway has an asphalt surface and is well maintained. The main highway between Lillooet and Lytton follows the Fraser Valley along the east side. From Lillooet this road continues northward to Quesnel through the village of Pavilion. This road is gravelled and well maintained. Gravelled roads run from Lillooet south to the mouth of Texas Creek, and from Pavilion through Upper Hat Creek to Ashcroft. Numerous smaller roads and trails criss-cross the country, especially in the Interior Plateau area. Through the Coast Mountains trails are poor. Consequently, traversing is very difficult.

With the exception of the bridge at Lillooet there are no highway bridges across the Fraser River. At Lytton, after high-water in late June, there runs a ferry large enough to transport automobiles. Else-

where, at Keefers, Inzman Creek and Pavilion there exist only small cable ferries; while at the latter location a one man rowboat constitutes the sole means of crossing the Fraser River.

RAILWAYS

The main lines of the Canadian Pacific and Canadian National Railways from Vancouver east pass through Lytton, Spences Bridge and Ashcroft. The C.PlR. follows the east side of Fraser Valley, the C.N.R. the west to Lytton, and thence along the Thompson Valley to Kamloops.

The Pacific Great Eastern Railway from Howe Sound to Quesnel passes through Lillooet and Pavilion. There is no rail connection between Lillooet and Lytton.

SETTLEMENTS AND POPULATION

Ashcroft, Lytton and Lillooet are villages, the population of each not exceeding two to three hundred persons. During the fruit packing season the population of Lillooet is considerably increased. The villages of Pavilion, Upper Hat Creek and Cache Creek consist only of a post office and a general store.

The population is a mixture of persons of European descent and local Indians. Many of these Indians have small farms or homesteads in Fraser Valley. Both Lillooet and Lytton Indians, and those from the Ashcroft area are of Shushwap stock. During the war of 1939-45 several hundred Japanese have been settled at Lillooet.

WATERPOWER

During the summer of 1946 the British Columbia Power Commission conducted a survey near the headwaters of Seton Creek about four miles south-west of Lillooet. In late summer work was commenced on the construction of a dam across Cayoosh Creek at the falls above the confluence of Cayoosh and Seton Creeks. The hydroelectric power developed here will be greater than the domestic requirements of Lillooet and its adjacent areas; and it is intended to utilize this surplus power in irrigating the sage-brush covered terraces of Fraser Valley.

FISHERIES

During the summer of 1945 under the supervision of the provincial government Department of Fisheries, work was commenced on the building of a

fish ladder on Fraser River immediately above the mouth of Bridge River. High water, during the summer of 1946, hampered further construction until the autumn. The site of this fish ladder is at a particularly rapid stretch of the river.

Local Indians have the privilege of killing salmon at all times of the year, provided they do not sell or ship, or cause to be sold or shipped the fish so caught. Their usual method of taking salmon is by means of a large net which resembles a butterfly net.

FARMING

In the Fraser Valley the climatic and soil conditions are very favorable for the raising of tomatoes, melons, celery and other market garden produce. Tomatoes are raised in large numbers, particularly by the Japanese and Chinese, for shipment to Vancouver and the prairie provinces. Fruit trees grow well, though only a small amount of fruit is shipped. The greatest difficulty in farming is caused by the scanty rainfall. Irrigation is a necessity, and long ditches have been dug from all streams on the nearby mountain sides. In general, mixed farming is practiced.

LUMBERING

Lumbering is a minor industry in the Lytton-Lillooet area. It is usually carried out on a small scale, a few men running a portable sawmill and cutting timber from Crown lands. Larger mills are established about two miles east of Keefers and on Kwotlenemo Lake at the head of Fountain Creek. A small box mill at Lillooet supplies the local needs for fruit packing cases.

PART 2

GEOLOGY OF THE AREA

STRATIGRAPHY

PREVIOUS WORK

In 1871 Dr. A. R. C. Selwyn, then Director of the Geological Survey, and Mr. J. Richardson made a reconnaissance from Yale, along the Fraser and Thompson Rivers to Kamloops. At this time he gave the name Jackass Mountain Group to an assemblage, several thousand feet thick, of coarse conglomerate, quartzite, sandstone and argillites typically represented at Jackass Mountain, some twelve miles south of Lytton on the east side of Fraser River.

From 1877-94 Dr. G. M. Dawson carried out extensive reconnaissance surveys in the general area of the Ashcroft Sheet, publishing a great wealth of detail in his report of 1894. Dawson's map of 1894 indicates his traverses, which for the most part followed numerous trails in the area. Much of the Coast Mountains, not easily accessible, Dawson provisionally mapped by means of binoculars. However, despite the reconnaissance nature of his work, Dawson's observations have proved to be remarkably astute. Dawson included the Jackass Mountain Group with other formations in British Columbia in the all inclusive Queen Char-

lotte Island Group which he considered to be of Lower Cretaceous age.

In 1912 N. L. Bowen assisted by E. L. Bruce, now head of the Department of Geology, Queens University, made a reconnaisance survey along the Fraser Valley from Lytton to Vancouver. Bowen correlated the Jackass Mountain Group, and other formations which he considered to be of Lower Cretaceous age with the Pasayten Group to the south.

No further work was done until 1945 when Dr. S. Duffell and Mr. K. C. McTaggart commenced work on the Ashcroft Sheet (Map 408A), adjacent to the Nicola Sheet to the east and the Hope Sheet to the south. With the exception of a very small part of the sheet, along the Fraser Valley south of Lytton, the only geological reports on the area are those of G. M. Dawson in 1877 and 1894. These proved of great value as guides. The Ashcroft Sheet was completed in 1946. It is expected, however, that no complete report on the area will be published until 1948- 49.

TABLE OF FORMATIONS

	Probable Age	Rock Type	App. Thickness
Kamloops Volcanic Group	Lower Miocene	Andesite, basalt, rhyolite tuff, breccia	2,500'
		Nearly flat lying volcanic flows	
Tranquille Group	Oligocene	Conglomerate, sandstone, carbonaceous shale, some tuff and agglomerate	2,000'
		Fresh water beds. Unconformably overly the Coldwater Group.	
Coldwater Group	Upper Eocene	Conglomerate, sandstone, carbonaceous shale, some tuff and basalt	3,000' plus
		Fresh water beds.	
Jackass Mountain Group	Aptian and Albian	Conglomerate, arkosite, shale	4,000' plus
		Brackish beds, becoming non-marine in upper section.	

TABLE OF FORMATIONS (Cont.)

	Probable Age	Rock Type	App. Thickness
Spence Bridge Volcanic Group	Aptian ?	Andesite, basalt, agglomerate, tuff, with interbedded conglomerate and sandstone in lower section.	2,000' plus?
		Fresh Water beds.	
Dewdney Creek Group	Upp. Jurassis ? and Low. Cretaceous	Conglomerate, arkosite, argillite, some tuff	10,000' plus
		Brackish and marine beds. Probably correlative of Hurley Formation and Eldorado Series #	

TABLE OF FORMATIONS (Cont.)

	Probable Age	Rock Type	App. Thickness
Ladner Group	Upp. Jurassic or ? Lower Cretaceous	Largely slates and siltstone, some phyllite and fine conglomerate Marine beds	2,000' plus ?
Nicola Group	Upp. Triassis	Andesite, feldspar porphyry, tuff, breccia, some conglomerate, sandstone, cherty argillite and limestone Probably fresh water beds in upper section.	10,000'

TABLE OF FORMATIONS (Cont.)

	Probable Age	Rock Type	App. Thickness
Cache Creek Series	Permian	Cherty quartzite, argillite, limestone Marine beds.	9,500' plus
Chilliwack Group	Carboniferous and later	Cherty and slaty argillite, limestone, phyllite, sericitic and chloritic schists, some conglomerate and quartzite, intercalated beds of andesite (greenstone) Largely marine, in part brackish beds.	5,000' plus ?

CHILLIWACK GROUP

This group consists of several thousand feet of slate, phyllite, crystalline limestone, sericitic and chloritic schists with intercalated beds of volcanics, conglomerate and quartzite. Cairnes (1943) has mapped it just south of the Ashcroft Sheet; and McTaggart (1946) has mapped it extending into the Ashcroft Sheet in the vicinity of Keefer's. The writer is of the opinion that lithologically similar beds he mapped near Lillooet are also members of the Chilliwack Group. Cairnes states that certain marine forms indicate an Upper Carboniferous or Lower Permian age for the Chilliwack Group. This group is usually highly folded, and intruded by peripheral stocks, dykes and sills of the Coast Range batholiths.

CACHE CREEK SERIES

The Cache Creek Series is very widespread in western and central British Columbia. Dawson (1894) divided the series into upper and a lower sections. The lower section consisted of phyllite, schist, cherty argillite and quartzite with some crystalline limestone and intercalated volcanics. The upper section consisted of several thousand feet

of limestone, quartzite and cherty argillite. The upper section is typically found in the Pavilion Lake area. The Chilliwack Group is probably a correlative of the lower section of the Cache Creek Series.

The Boston Bar Series along the Fraser River north of Hope were correlated by Dawson (1877) with what he considered to be Cache Creek beds occurring at Texas and Cayoosh Creeks in the Lillooet area, and which he considered to be of Lower Carboniferous age. Probably the same series was described by Bateman (1911) as occurring along Siwash Creek south of Boston Bar, and named Siwash Series. Camsell (1919) reports the same series of rocks in the valley of Co~~c~~quihalla River, east of Hope, extending northward to Boston Bar. He considered them to be of Cache Creek age. Cairnes (1937) states that the Fergusson Series on Bridge River is probably a correlative of what he termed Cache Creek beds near Lillooet, which latter were described by Dawson (1894) along Cayoosh Creek. In using the term Cache Creek Series the writer will confine his description to Dawson's upper section.

Cache Creek Series, at Pavilion Lake, northeast of Lillooet, is fossiliferous in some horizons and

is characterized by the large foraminifera *Fusilina*. The series is considered by Crockford and Warren (1935) to be Permian in age. Cockfield (1944) collected fossils in the Nicola area which suggested a Pennsylvanian age.

Drysdale (1913) considered the Cache Creek Series (including Dawson's upper and lower sections) to total some 15,000 feet. Daly (1915) gives a thickness of 13,700 feet for the Cache Creek Series east of Kamloops, evidently also including both upper and lower sections of Dawson.

NICOLA GROUP

This group consists, for the most part, of pyroclastics and volcanic flows, estimated by Rose (1912) to be 10,000 feet thick. Duffell (1946) describes this group, occurring in the Ashcroft area, as consisting of green andesites, tuffs and breccias, argillaceous and arenaceous beds and fossiliferous limestone. In the Nicola area, south of Kamloops Lake, Cockfield (1944) describes this group as having, in addition, some conglomerate. This same group is found in the Princeton area, to the south of the Nicola area, and is described by Rice (1945) as containing red and

purple feldspar porphyries and cherty argillite.

Near the head of McGillivray Creek, on the west side of the Fraser River between Lillooet and Lytton, the writer noted extensive flows of purple feldspar porphyry, apparently similar to those described by Rice (1945), and which may be of Triassic age. They may also be Tertiary, although the writer has tentatively correlated them with volcanics in the Spences Bridge area, which Duffell (1946) considers to be of Lower Cretaceous age.

LADNER GROUP

This group consists largely of slates, with some schist, phyllite, quartzite and fine conglomerate. The age is placed by Cairnes (1943) as Upper Jurassic and possible Lower Cretaceous. The group is typically found between Boston Bar and Hope, and to the east of Fraser River. McTaggart (1946) tentatively correlated beds, occurring on the Ashcroft Sheet near Keefer's, with the Ladner Group, and considered them to be of Middle to Upper Jurassic age.

DEWDNEY CREEK GROUP

As it occurs in the area of Mount Dewdney

to the east of Hope, this group is described by Cairnes (1943) as consisting of tuff, agglomerate, arkose, argillite and conglomerate. Cairnes considered this group to be of Lower Cretaceous age, though with Upper Jurassic affinities. Mr. K. C. McTaggart (1946)# mapped a succession of rocks at Lytton which he considers to be a correlative of the Dewdney Creek Group. This succession lies in faulted contact with the intrusives of the Coast Mountains, and consists of some 6500 feet of tuffaceous arkose, conglomerate and shale, overlain by 2200 feet of laminated argillite and siltstone with some tuffaceous arkose. The succession is non-marine at the base and marine toward the top. Overlying this succession, possibly unconformably, is the Jackass Mountain Group, the basal member of which is a bed of conglomerate, several hundred feet thick. Overlying this conglomerate, McTaggart described several thousand feet of tuffaceous arkose, conglomerate and argillite of non-margin origin, which he considers to be of Albian age.

During the summer of 1945 McTaggart collected fossils from these beds. Dr. F. H. McLearn reported on the fauna as follows:-

# Personal Communication

Unionidae or Sphaeridae
Belemnites sp.
Trigonia sp .
Douvilleiceras ? sp.
Pecten sp.
Pleuromya cf.vancouverensis (Whiteaves)
also cf.russelli (Anderson)
Lima sp.
Aucella ? sp.
Acroteuthis sp.
Nemodon ? sp.

Dr. McLearn considered the assemblage to be probably of Lower Cretaceous age.

Dr. W. A. Bell reported on the flora as follows:-

Ferns

Cladophlebis virginiensis (Fontaine)
forma acuta
Coniopteris heterophylla (Fontaine)
Sphenopteris latiloba (Fontaine)
Ruffordia ? geopperti (Seward)

Cycladeoids

Pterophyllum ? concinnum ? (Heer)

Angiosperms

Rhamnites sp.
Sapindopsis variabilis (Fontaine)
Trochodendroides potomacensis (Ward)
Araliaephyllum sp.
Cinnamonoides ovalis (Dawson)
Ficus ovatifolia (Berry)
Juglandites sp.
Laurop-hyllum sp.
Proteoides ? daphnogenoides ? (Heer)

Incertae sedis

Podozamites sp.

Dr. Bell considered the florule as a whole to indicate an Aptian and Albian age. He states, "Cladophlebis sp. is a new species that was noted previously in a collection from a part of the Skeena Group. It was there accompanied by some Jurassic hold-overs; but the florule as a whole was considered to be provisionally Aptian."

JACKASS MOUNTAIN GROUP

The basal member of the Jackass Mountain Group is a massive conglomerate, the cobbles being mainly of leucocratic diorite, quartzite, and some volcanic, probably varying in thickness from 500 to 1500 feet. It is overlain by several thousand feet of massive beds of arkose, quartzite and shale. The typical section occurs at Jackass Mountain, just to the west of Kanaka Mountain, some twelve miles south of Lytton.

At this locality Dawson (1894) collected the following fossils.

Belemnites impressus (Gabb)
Pecten meekiana (Whiteaves)
Ancyloceras percostatum (Gabb)
Crioceras latus (Gabb)
Pholadomya vancouverensis (Whiteaves)
Arca cartesoni (D'Orbigny)
Cucullaea sp.

These he provisionally considered to indicate an age equivalent to the Lower Shasta of California, of lowermost Lower Cretaceous age.

The writer unsuccessfully searched for Dawson's fossil locality, and is of the opinion that the locality is not in the Jackass Mountain Group, but below the conglomerate.

At the mouth of Stein Creek, near Lytton, Dawson (1894) collected non-marine forms, including *Goniobasis* ? sp. and Selachian fish remains. These beds, according to Mr. K. C. McTaggart # overlie the Jackass Mountain Group, and are possibly of Albian age.

Dawson (1894) also reports collecting *Aucella mosquensis* var. *concentrica* on the west side of Fraser River three miles north of Intlpam Creek. At this locality the writer collected *Aucella* sp. These beds are highly folded, being intruded by diorite; and are considered by the writer to underlie beds of Jackass Mountain Group age. Dawson also collected what appeared to be the crushed shells of *Ostracoda*, and fish bones from the shale at the mouth of Botanie Creek just north of Lytton. The age of these beds is uncertain; but the writer, who examined them briefly, is of the opin-

Personal Communication

-ion that the conglomerate, indurated arkose and shale are part of the uppermost Jackass Mountain Group, and possibly of the same age as the beds at the mouth of Stein River. These beds at Stein River also contain fish bones, and are considered by McTaggart, as previously mentioned, to be Albian in age.

Dawson (1894) correlated these beds at Botanie Creek with Cretaceous beds in the Fraser Valley, and in the opinion of the writer, correctly so. He also correlated these beds with a series, some 5,000 feet thick, of conglomerate, sandstone and argillite at Ashcroft. A large, coarsely ribbed Pecten from the Ashcroft beds was described by Dr. T. W. Stanton as follows, "So far as the characteristics are preserved, this specimen might be Jurassic, Cretaceous or Tertiary; but it is probably from the Jurassic". The genus Pecten, is living at the present day, so its presence is not indicative of the age of these beds.

Duffell (1946) considers these beds at Ashcroft to be of Middle and Upper Jurassic age, and correlates them with beds near Keefer's which McTaggart (1946) tentatively considered to be of Ladner Group age.

From the same locality in which McTaggart in 1946 obtained the Angiosperms previously mentioned, Dawson in 1890 (see p.148 of 1894 Report) collected plant remains. On these he reported as follows:-

> Platanus obtusiloba (Lesquereux) This is a species found in the Dakota Group in Nebraska.
>
> Magnolia tenuifolia ?(Lesquereux) This is found in the Dakota of Nebraska and also in the Dunvegan Group of Peace River.
>
> Meninspermites allied to M.grandis of the Dakota Group, but probably specifically different.
>
> Laurophyllum Several leaves referable to this genus, and near the Dakota species.
>
> Sequoia A fragment which may be S.rechenbachii
>
> Phragmites sp. or Carpolites sp.

Dawson evidently considered the whole assemblage to be of Lower Cretaceous age. This particular locality is in the sandstone and shale beds above a conglomerate bed of undetermined thickness. Although the writer has only briefly examined these beds he is of the opinion that they lie within the Jackass Mountain Group.

Pasayten Group, occurring in the Coquihalla area to the east of Hope, is probably of the same age

as the Jackass Mountain Group. Lithologically the two groups have a marked similarity. At Jackass Mountain the writer measured a thickness of approximately 1,500 feet for the basal conglomerate member, (See Plate 8). In the Yale district Cairnes (1923) estimated a thickness of 1,400 feet for the conglomerate member of the Pasayten Group. Cairnes (1943) considered the succession of conglomerate, arkose, argillite and tuffs to be of Lower Cretaceous age. Camsell (1911) reports that Aucella piochii and Prionocyclus sp. occur in the Pasayten Group.

Bowen (1912) was of the opinion that the Lower Cretaceous beds along the Fraser River south of Lytton were correlatives of the Pasayten Group, and similar in fossil content to the Lower Cretaceous Shasta Series of California.

The distribution of correlatives of the Jackass Mountain Group is very uncertain. Cairnes (1943) considered the Jackass Mountain and Dewdney Creek Groups to be of the same age, that is, Lower Cretaceous and possibly in part Upper Jurassic. Camsell (1919) reported a patch of conglomerate on the west bank of the Fraser River at Hope, which he thought

to be of Cretaceous age. The pebbles are of granite, granodiorite, slate and volcanics. He states that here it rests on the granodiorite batholith, but farther north rests unconformably on highly folded slates. Cairnes (1920) reported the same patch, and also tentatively considered it to be of Lower Cretaceous age. In the Coquihalla area he also reported lithologically similar patches of conglomerate on Cedar Creek, on a ridge west of Tulameen Mountain and on the summit of Silver Peak. The latter he reported to be 1,500 to 2,000 feet thick, resting on the p lutonic rock of the coast range batholith.

Cairnes (1943) described a series of some 5,000 feet of beds at Harrison Lake as being of Lower Cretaceous age. The basal member is a thick conglomerate of granitic detritus, overlain by light colored sandstones and sandy, grey argillite. These in turn are conformably overlain by massive, pale green beds of tuffaceous sediments. Dr. S. H. Crickmay# is of the opinion that these beds are definitely of Lower Cretaceous age. In his report (1930) he identified the following fossils from these beds:-

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Aucella acutistriata (Crickmay)
Aucella catamorpha (Crickmay)
Aucella spasskensoides (Crickmay)
Aucella cascadensis (Crickmay)
Aucella canadiana (Crickmay)
Aucella crassicollis (Keyserling)
Aucella solida (Lahusen)
Aucella harrisonensis (Crickmay)
Aucella teutoburgensis (Weerth)
Entolium aucellarum (Crickmay)
Belemnites sp.
Cylindroteuthis baculus (Crickmay)
Pachyteuthis eocretacicus (Crickmay)
Mclearnia mcleanrni (Crickmay)
Astarte barbara (Crickmay)
Phylloceras aff.knoxvillense (Stanton)
Quoiecchia aliciae (Crickmay)
Pleuromya harrisonensis (Crickmay)
Homolsomites poecilochomus (Crickmay)
Yaadia lewisagassizi (Crickmay)

At the south end of Harrison Lake the Agassiz Group is described by Cairnes (1943) as consisting of a basal conglomerate, some 3,000 feet thick, overlain by 5,000 feet of sandstone and abundant black argillite. No fossils have been found in this group; but an Upper Jurassic ammonite was found in similar argillaceous beds near Harrison Lake; and Cairnes tentatively placed these beds as of Upper Jurassic age. The evidence is indeed scanty. Lithologically, the Agassiz Group resembles the Jackass Mountain Group.

Dawson (1894) after examining Selwyn's Jackass Mountain Group south of Lytton, placed it with other Lower Cretaceous beds in British Columbia in the

all inclusive Queen Charlotte Island Group. According to Anderson (1938), Whiteaves described many fossil invertebrates from the Lower Cretaceous beds of the Queen Charlotte Islands as being identical with, or analogues of, molluscan species occurring in the Horsetown Group, of Aptian age, in California.

SPENCE BRIDGE VOLCANIC GROUP

The writer is of the opinion that this group is younger than the Jackass Mountain Group. The beds, as described by Duffell (1946), consist of purple, red and green andesites, dark brown basalts, tuffs, breccia and agglomerate, with some interbedded conglomerate and tuffaceous sandstone. Duffell believes them to be of Lower Cretaceous age. Rice (1945) also considered the Spence Bridge Group to be of Lower Cretaceous age, and younger than the Pasayten Group.

There has been considerable difference of opinion as to the age of the Spence Bridge Volcanic Group. Correlations are difficult to make on lithologic evidence, as volcanic beds are local in character. In 1877 Dawson (1894) placed this group stratigraphically below the Lower Cretaceous beds in Fraser Valley. Later, however, because of their association with the

Kamloops Volcanic Group he placed them with these Tertiary beds.

Drysdale (1912) described a part of the Spence Bridge Group as follows:- "A coarse conglomerate near the base of the Spence Bridge Volcanic Group is composed of much granitic material, with boulders arranged overlapping one another eastward. The old fluviatile deposit appears from this to have been laid down in a river probably flowing from the Coast range into an interior basin to the east, where the sediments were soon entrapped and protected from erosion by younger volcanics."

Drysdale (1912) was of the opinion that the Spence Bridge Volcanic Group was probably of the same age as the volcanics in the Hazelton Group. From tuffaceous beds on the western slopes of the Pimainus Hills, east of the Spences Bridge, Drysdale collected the following plants, which were identified by W. J. Wilson.

Nilssonia cf. schaumburgensis (Dunker)
Taenopteris cf. T. orovillensis (Fontaine)
Sequoia reichenbachii (Heer)
Podozamites lanceolatus (Lindley & Hutton)
Podozamites cf. P. gramniaefolia
Sagenopteris cf. S. paucifolia (Ward)
Cladophlebis cf. C. falcata montanensis (Fontaine)

Cladophlebis cf. browniana (Dunker)
Oleandra sp.
Equisetum ? sp.
Sphenolepidium sp.

Wilson considered the assemblage to be of Lower Cretaceous age, probably equivalent to Kootenay flora, but with a definite Jurassic aspect. Dr. F. H. Knowlton, to whom the collection was later submitted, likewise considered them to be Kootenay flora, with decided Jurassic affinities.

COLDWATER GROUP

This group, occurring to the south of Kamloops Lake consists of conglomerate, sandstone, shale, tuff, and some coal. According to Cockfield (1944) these beds are of Upper Eocene age. Drysdale (1912) had previously considered them to be Eocene, and questionably Oligocene, correlating them with what he termed the Silikameen Beds. At Princeton, and elsewhere in the Silikameen area, Rice (1945) described the Princeton Group (probably the same as Drysdale's Silikameen beds) as consisting of the conglomerate, buff colored sandstone, and brown shale. Rice states that these beds are of Eocene or Oligocene age. In places these sediments are associated with, and have intercalated beds of mauve and green andesites and dark brown basalt.

Some thirty miles north of Lillooet, MacKenzie (1920) correlated the French Bar Formation with the Coldwater Group. This formation consist of approximately 2,000 feet of conglomerate and sandstone, the conglomerate boulders having been derived mainly from detritus of the Coast range.

KAMLOOPS VOLCANIC GROUP

The uppermost beds of the Interior Plateau in the Kamloops area are of relatively flat lying basic volcanic flows, probably two to three thousand feet thick. Rice (1945) describes these rocks as "dark brown, mostly amygdaloidal, flat lying 'plateau' basalt; and red, purple and grey 'valley' basalt, commonly vescicular and flat lying." These basalts are rusty-red weathering, and present a most striking appearance.

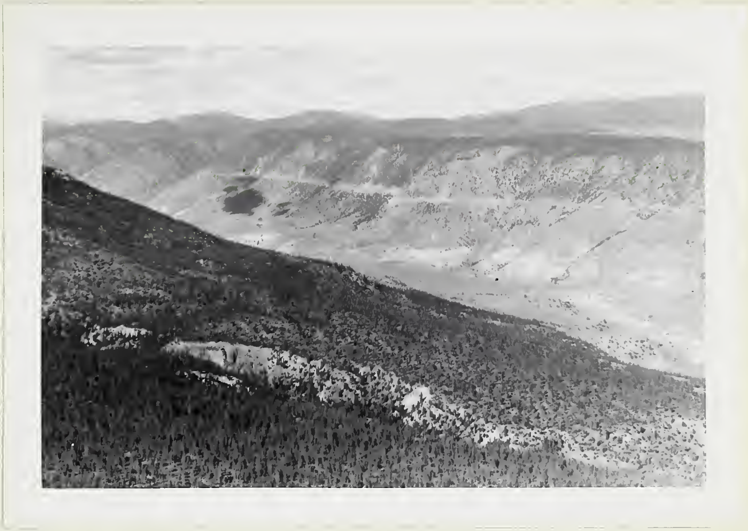
Cockfield (1944) reports white to pale grey rhyolite in the Nicola area south of Kamloops Lake. The writer has observed similar rhyolite in volcanic beds to the east of Lillooet. These volcanic beds in the Kamloops area are considered by Rice (1945) to be of post-Oligocene age. Cockfield (1944) was of the opinion that most of the Tertiary volcanic rocks were probably of Oligocene age, but that some may be of

Miocene or even of later age.

FRASER VALLEY

NORTH OF LILLOOET

PLATE 5



View from the Camelsfoot Mountains, west of Pavilion, looking north-east along Fraser Valley.

In the foreground is the deeply incised valley of Red Creek, the cliffs of which, shown here, are of red weathering basalt. The entrenched Fraser River is not visible. Having been rejuvenated in post-Pleistocene time it has cut a deep canyon through the horizontally stratified Pleistocene 'white silts' seen in the valley. The hills in the right background are the Pavilion Mountains of Cache Creek limestone.

Note the Pacific Great Eastern Railway line on the east bank of the Fraser River.

STRUCTURAL RELATIONSHIPS ALONG FRASER RIVER

ABSTRACT

The Coast Range batholiths have intruded the Permian? sediments, and are in faulted contact with the Lower Cretaceous sediments. The gneissosity of these plutonic rocks coincides with the regional strike of the Permian? rocks, and also with the general trend of the Coast Mountains, which is to the northwest.

Fraser Valley in [illegible] sheet occupies a line of faulting along the eastern flank of the Coast Mountains. Both step-faulting and graben faulting are likely present along Fraser Valley.

PERMIAN? ROCKS

Chilliwack Group

These beds consist of highly folded phyllite, schist, cherty argillite and some crystalline limestone, intruded by the plutonic rocks of the Coast Range. The general strike of these Palaeozoic sediments is to the northwest, being parallel to the general trend of the mountains.

In part, at least, the granodiorite intrusives were of the 'permissive' type. Along Cayoosh Creek near Lillooet the Chilliwack sediments are not generally highly contorted, the intrusives having gently eased upward and penetrated along bedding planes, so that in places there is lit-par-lit injection. This relationship was also observed by Bowen (1912) near Agassiz, where granitic masses intrude cherty slates. He states, "these receive numerous dykes and sills from the granite beneath, but preserve their regional strike and dip. In short, there is shown the most absolutely convincing evidence of replacement, rather than displacement, of the sediments by the invading magma." In the Coast Mountains, and in the adjacent stocks along Fraser Valley, there are numerous outliers and inclusions of presumably Chilliwack sediments.

The sequence of the orogeny of the Coast Range, and the folding of the Palaeozoic sediments is open to argument. It is not certain whether the Coast Range batholiths pushed up the overlying sedimentary rocks, or whether the folding of these rocks caused a release of presure which allowed the magma to rise. Perhaps both principles were involved. At all

events, there is evidently a structural control to the parallel relationship of the regional strike of the Palaeozoic sediments and the regional trend of the long axes of the batholiths and related stocks.

JURASSIC AND? CRETACEOUS ROCKS

Kanaka Batholith

Structural Relationships

The name Kanaka Batholith has been applied by the writer to a batholith of granodiorite at Kanaka Mountain. The batholith occupes a large part of the Nicoamen Plateau to the east, and is an eastward extension of the Coast Range batholiths, extending southward into the Coquihalla area. Along Fraser Valley this batholith is in faulted contact with the Lower Cretaceous sedimentary rocks. To this fault the writer has applied the name Siska Creek Fault.

From Thompson River to the southern edge of the Ashcroft Sheet, a distance of some fifteen miles, the writer recorded several attitudes of gneissosity along the western contact. These showed remarkably little deviation from a mean of approximately 325 degrees, which is the direction of the long axis of

the batholith or stock, and as pointed out previously, with the regional strike of the intruded Palaeozoic sediments was observed at several other places along Fraser Valley. Further, the dip of the flow layers was approximately 50 degrees to the east at all localities where attitudes were measured. This again showed a marked accordance with the dip at several other localities as far north as Lillooet.

Siska Creek Fault

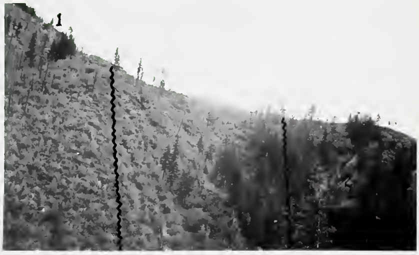
The writer has so named this fault because of an excellent exposure he studied along Siska Creek which cuts at nearly a right angle across the fault. This fault marks the contact between Kanaka Batholith and the sedimentary Lower Cretaceous beds. From just south of Lytton the fault can be traced intermittently to the southern edge of the Ashcroft Sheet.

The idea of a faulted contact between the Coast Range intrusives and the Mesozoic sedimentary rocks along Fraser Valley is not a new one. Bowen (1912) referred to the contact between the intrusives and Cretaceous rocks near North Bend as follows, "close to the granites the attitude may be nearly, or quite vertical. The granite does not, however, give any evidence of being intrusive. The relation shown is due

SISKA CREEK FAULT

View looking south across Siska Creek.

PLATE 6



1 - Outcrop of Jurassic? granodiorite
2 - Outcrop of Lower Cretaceous arkose and siltstone

The fault,as shown above,has a shear zone from 200 to 300 feet wide. The trace of the shear zone is indicated in the topography by a shallow hollow along the contact,caused no doubt by the fact that the sheared rock is more easily eroded than the harder rock on either side .

to the down faulting of the Cretaceous beds." Again, referring to the age of what he termed biotite granite intrusives he stated, "It is probably pre-Cretaceous in age, although the only observed contact with the Cretaceous was a faulted one". As a result of his structural studies along Fraser Valley from Lytton to Hope, Bowen postulated the idea of a graben structure for the Lower Cretaceous sedimentary beds. In his 1912 report he states, on p.108, "the Fraser Valley from Lytton to North Bend follows a line of graben faulting."

Likewise, Camsell (1919) came to the same conclusion in commenting on the position of a patch of presumably Lower Cretaceous conglomerate near Hope. This patch has previously been referred to on p.37. Camsell states, "The position of this conglomerate can only satisfactorily be explained by down-faulting along a north and south line, a line which was afterwards followed by the Fraser River in cutting out is valley".

The exposure at Siska Creek indicates that here the fault is striking just west of north, and dipping steeply to the west. No alteration of the granodiorite was evident; but the sedimentary beds adjacent to the fault zone are tilted at a high angle and generally smashed. The sediments show slickenside in several

directions. Some breccia is present, and considerable carbonaceous gouge, apparently derived from the crushing of argillite. Carbonatization is general in the sediments adjacent to the shear zone. The shear zone is apparently two to three hundred feet wide. No evidence could be obtained as to the amount of displacement, but it is probably in the order of thousands of feet.

Botanie Batholith

Structural Relationships

The Botanie Batholith is a northward extension of the Kanaka Batholith, and is defined from the confluence of the Fraser and Thompson Rivers, through Botanie Mountain to the southern end of Fountain Ridge, a distance of some twenty five miles. The nature of its contact with the Lower Cretaceous? volcanics to the east is not definitely known, but is probably faulted. North of Siwhe Creek the batholith is in faulted contact with Lower Cretaceous sediments along the east side of Fraser Valley.

This batholith shows some differentiation from granodiorite to quartz-diorite and more mafic varieties. In this respect it differs from the Kanaka

Batholith which is largely granodiorite. Cache Creek inclusions and outliers, whereas infrequently found in the Kanaka Batholith, are numerous and extensive in the Botanie Batholith. The gneissosity is in general accordance with that on the western edge of the Kanaka Batholith.

Botanie Creek Fault

Along Botanie Valley, in a general north and south direction, there is a fault zone, marked at the mouth of Botanie Creek by an escarpment of diorite intruded by dykes and sills of pink pegmatite. The texture of this pegmatite is that of coarse granite. The attitude of this fault could not be determined; but minor faults in the main fault zone indicate a nearly vertical dip. It is probable that this nearly vertical attitude is not maintained to any great depth.

The writer had an excellent opportunity to study this fault zone along the railway cutting of the Canadian National Railway which follows the north bank of the Thompson River. Three sequences of intrusives were noted, the earliest being a moderately basic diorite, and lastly intruded by a pegmatite containing pink orthoclase. The fault zone is several hundred yards wide, and consists of numerous parallel faults.

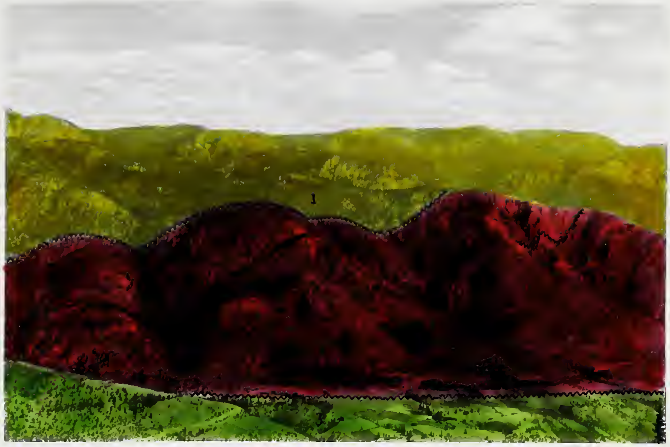
McGILLIVRAY CREEK SHEAR ZONE

View looking eastward across Fraser Valley and the mouth of Cinquefoil Creek toward the Interior Plateau. The southern end of Fountain Ridge can be seen in the lower left corner.

The granodiorite is probably in faulted contact with the argillaceous sediments, at the southern end of Fountain Ridge. Its contact with the Lower Cretaceous? volcanics is apparently faulted. A definite shear zone is indicated mid-way in the granodiorite stock itself. The stock has inclusions of phyllite and schist, probably from the Chilliwack Group.

Note the high, flat topped volcanic hills of the Interior Plateau, separated by deeply incised valleys. These hills are of nearly flat lying flows of basalt and andesite.

PLATE 7



1	Tertiary? and Lower Cretaceous volcanics
2	Jurassic? granodiorite
3	Lower Cretaceous argillite and arkose

The escarpment is a very striking topographic feature, and Dawson (1894) was of the opinion that it was a fault scarp.

McGillivray Creek Fault

The northern part of the Botanie Batholith has a marked fault zone extending from south of McGillivray Creek to the mouth of Cinquifoil Creek. This fault zone is characterized by intense shearing of the diorite, and consequent kaolinization? and mineralization. In this region, copper minerals in particular are found in shear zones in the plutonic rocks.

LOWER CRETACEOUS ROCKS

Jackass Mountain Unconformity

At Jackass Mountain, twelve miles south of Lytton, the conglomerate zone of the Jackass Mountain Group is some 1,500 feet thick. Whether it lies unconformably on the underlying arkose, quartzite and argillite beds has not been proved; but the writer is of the opinion that an unconformity does exist.

In the summer of 1945, near Lytton, Mr. K. C. McTaggart# mapped a patch of rocks which he considered

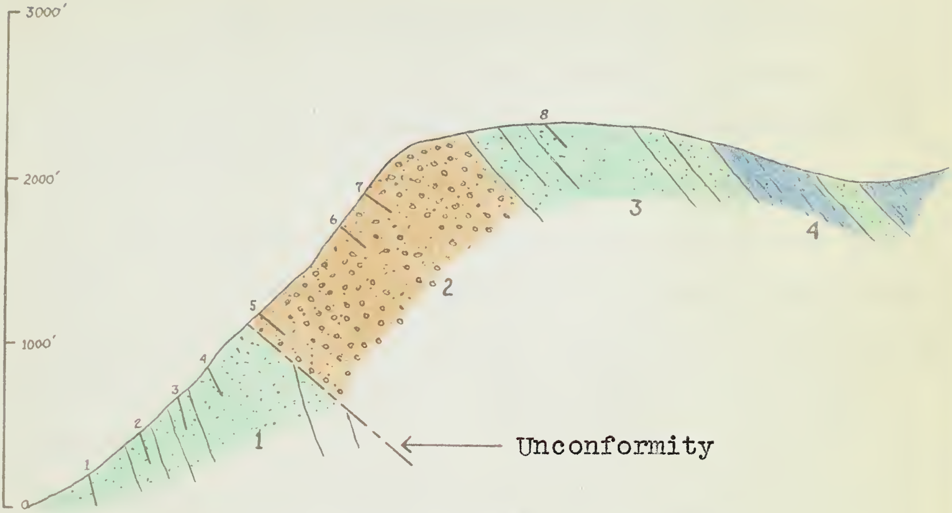
#Personal communication

to be part of the Jackass Mountain Group, overlying a sedimentary series which he also considered to be a correlative of the Dewdney Creek Group. He was of the opinion that an unconformity separated these two groups, near Lytton.

At Jackass Mountain the writer measured a section which apparently indicates an unconformity between the Jackass Mountain Group and the underlying sediments (see Plate 8). Within, and above the conglomerate zone the strata dipped from 30 to 45 degrees to the east; while below the conglomerate zone the dips varied from 65 to 75 degrees to the east. This evidence is by no means taken as conclusive. Lithologically the rocks are much the same both above and below the conglomerate zone. The idea of an unconformity is possibly supported by the fact that all fossil fauna collected was in a horizon underlying the conglomerate zone; although numerous fragments of plant remains were found above the conglomerate. Such evidence must, however, be taken with reserve, as pointed out by Twenhofel (1936). In referring to fossil evidence as indicative of an unconformity, he has this to say, "Changes in fauna and flora indicate changes in environment. Mere differences in species do not suffice, or even differences in genera, since one may find these differences

PLATE 8

JACKASS MOUNTAIN UNCONFORMITY



Horizontal Scale: 1" to 1000'

4 Argillite and siltstone

3 Mainly arkose, some interbedded sandstone

2 Mainly conglomerate, some lenses of arkose

1 Mainly sandstone, some interbedded arkose

1 - 4 incl. --- Dips of 65 to 75 degrees
5 - 8 incl. --- Dips of 35 to 45 degrees

N.B. Lithology based on field examination only.

at present on different parts of the same sea bottom not very far removed from each other".

Falls Creek Fault Block

West of Kanaka Mountain the Lower Cretaceous sediments in Fraser Valley are faulted, probably forming several fault blocks. Two major fault zones, approximately four miles apart, were studied by the writer. To the enclosed area of rock he has applied the above name. This block is bounded on the east by the Siska Creek Fault, or its extension. The fault at the north strikes roughly northeast; while that at the south strikes to the south east. The western contact is also, presumably, the extension of a fault mapped by McTaggart (1946) on the west side of the Fraser Valley in the Lytton area. This fault block appears, then, to be completely bounded by faults, and may possibly be a graben.

Fountain Ridge

Fountain Ridge extends from the mouth of Cinquefoil Creek to the confluence of Bridge and Fraser Rivers at the Big Bend of the Fraser River, near Lillooet, a distance of over twenty miles. The structure of the ridge is generally synclinal, being an ex-

-tension of the rocks forming a height of land between the Camelsfoot Mountains and Bridge River. On the east the ridge is closely bounded by a shear zone extending in a northerly direction along Fountain Valley. To the east of this shear zone lie volcanics, probably of Lower Cretaceous age.

LOWER CRETACEOUS AND? TERTIARY ROCKS

Volcanics

These volcanic flows form the deeply entrenched, rolling plateau extending eastward from the Botanie Batholith. At Pavilion these volcanics cross the Fraser River; and their faulted contact with the Lower Cretaceous sediments strikes generally along Red Creek. The Camelsfoot Mountains, a gently rolling height of land, consist largely of these volcanics.

GLACIATION

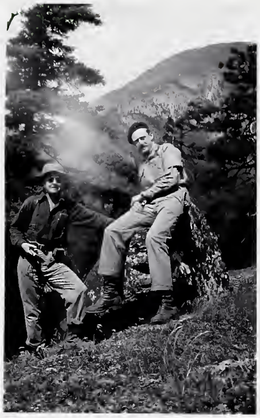
GLACIAL STRIAE

Dawson (1894) made numerous observations on the directions of glacial striae in the Kamloops, Lytton and Lillooet areas, and came to the conclusion that the general movement of the ice sheet was to the south-east. Dawson noted striae at 7,000 feet and concluded that the ice must have been in places over 6,000 feet thick. He was of the opinion that the Cordilleran region had a considerably higher level than it does today, and thought that subsidence coincided with the retreat of the ice.

The writer observed many glacial striae on the ridges and hilltops to the east of Fraser Valley; and these all supported the idea of a south-easterly movement of the ice sheet. Striae observed to the west of Fraser Valley, in the Coast Mountains, were by no means so uniform in direction, and generally coincided with the slope of the present topography. This indicates that although the continental ice sheet, probably several thousand feet thick, moved in a south-easterly direction across the Interior Plateau, it was bounded on the west by the alpine glaciation of the Coast Mountains. As the trend of these mountains is to the south-east, the ice sheet apparently moved parallel to the Coast

GLACIAL ERRATIC

PLATE 9



View looking north toward Kanaka Mountain,twelve miles south of Lytton. This glacial erratic is at an elevation of 2500 feet above sea level,some 1500 feet above Fraser River.

Glacial striae in this vicinity indicate a general south-easterly movement of the Pleistocene ice sheet.

Mountains.

FLUVIO-GLACIAL DEPOSITS

The Fraser River has, by rejuvenation, cut a deep and narrow channel through the fluvio-glacial material in its valley. Along the slopes of Fraser Valley are numerous terraces. The writer made a good many measurements of altitude on a number of these terraces and found may to coincide at two and sometimes three distinct levels. These levels were generally at altitudes of from 1,000 feet to 1,500 feet, and are evidently river terraces. They have been cut from fluvio-glacial deposits of silt, sand and gravel, which in late Pleistocene time must have filled the valley.

Horizontally stratified, buff colored silts, termed 'white silts' by Dawson (1894), are prominent in the Fraser Valley near Pavilion. Here the Fraser River has cut a narrow gorge, some 200 feet deep, through these silts and the underlying glacial deposits of gravel. Dawson assumed these silts to have been formed by a flooding of Fraser Valley following the subsidence of the land mass in late Pleistocene time. Presumably, Dawson meant a marine transgression, which does not seem likely.

The writer has closely examined these silts and the associated glacial deposits of sand and gravel, and is of the opinion that the former are lake deposits, formed during a period when the Fraser Valley was temporarily dammed by ice and moraine material. These views will be further enlarged upon in Part 3.

GEOLOGICAL HISTORY AND REGIONAL TECTONICS

PALAEOZOIC ERA

In the area comprising Kamloops, Lytton, Hope, and Lillooet, no pre-Carboniferous, and probably no pre-Permian, sedimentary beds have been found. For this reason it is considered that this portion of British Columbia must have been a land mass during the greater part of the Palaeozoic era. It is probable that Cascadia, as this land mass is named, existed as far back as Precambrian time, and persisted throughout the Palaeozoic era, contributing largely to the sedimentation in the Rocky Mountain geosyncline, and to basins in the present regions of Alaska and Yukon.

During Upper Carboniferous time, or later, the land mass of Cascadia, which by this time had probably been worn down to a low lying peneplain, gradually subsided beneath the encroaching Vancouver sea which is presumed to have advanced from the west. In this sea were deposited the sands, muds, and calcareous ooze which later formed the quartzites, phyllites, and crystalling limestone of the widespread Cache Creek series.

The nature of the basin of deposition at

this time must have been a broad miogeosyncline. As the land mass being inundated was probably very low, it is natural that the clastic sediments would be fine grained. In evidence, the coarsest sedimentary beds of the Cache Creek Series are sandstones and quartzites. These beds, although patchily distributed, are of wide extent throughout the western interior of British Columbia, extending, according to Crockford and Warren (1935), from the International Boundary northward into Alaska. From fossil evidence, such as the abundance of crinoid stems, corals and foraminiferae in the limestone beds it is probable that the Vancouver sea was warm, or moderately so. There was some volcanic activity during this period; and intercalated beds of agglomerate are found in the Cache Creek Series.

MESOZOIC ERA

The end of the Palaeozoic era was marked by local uplift and deformation, as indicated by the unconformity between the Cache Creek Series and the overlying Nicola Group. According to Drysdale (1912) some coastal regions underwent continuous sedimentation from Permian into Triassic time. The sediments of the Nicola Group, deposited during a submergence in Upper Triassic time, consist of sandstone, argillite

and limestone, probably indicating moderately low relief in the existing land mass. Continuous sedimentation from Permian to Triassic time would also indicate that orogeny was moderate. As in the Permian period, volcanism contributed tuffaceous and agglomeratic beds to the basins of deposition. It is probable that volcanism was continuous from Permian into Triassic time. As with the Permian beds, the sediments become less clastic and more calcareous in the upper part of the Nicola section, indicating a progressive transgression of the sea. The fauna similarly indicates a moderately warm environment.

At the end of the Triassic period the land again rose, and probably remained high during most of Lower Jurassic time. During Middle Jurassic time the land mass subsided, and locally at least, remained so into early Upper Jurassic time, as shown by the conformable succession at Harrison Lake. Local orogeny in late Upper Jurassic time caused, in the Harrison Lake area, an unconformity between beds of this age and those of early Upper Jurassic time.

Volcanism was prevalent during Middle and Upper Jurassic time. Thick beds of lavas, tuffs and agglomerates were intercalated in the sandy and muddy

sediments. Topographic relief during these times was probably moderate, the basins of sedimentation being shallow and brackish. The sea was probably cooler than in Triassic time, as corals and crinoids are not in evidence.

During Upper Jurassic time the Jurassic Revolution is considered to have given rise to the initial stages of the Coast Mountains. Great batholiths of diorite provided the source for the thick conglomerate beds of late Upper Jurassic age. It is probable that the seas withdrew during this time, leaving linear basins of deposition into which were quickly accumulated coarse gravel, sand and some mud.

Local rising and falling of the land mass occurred from then on into Lower Cretaceous time. Indeed, no sharp demarkation can at present be drawn between beds of late Upper Jurassic and early Lower Cretaceous ages. The orogeny of the Coast Mountains probably continued into Lower Cretaceous time, accompanied by active volcanism.

Sedimentation during Lower Cretaceous time was rapid, and the clastics consequently coarse. Volcanism was markedly active during late Lower Cretaceous time, contributing largely to the Spence Bridge Vol-

-canic Group. It is probable that the Laramide Revolution began at this time, giving rise in late Upper Cretaceous ~~time~~ to a height of land where the Rocky Mountains now stand. Such an orogeny would have caused a retrogression of the sea in the Kamloops-Lytton area, and probably over a much wider area, as indicated by the absence of sedimentary beds from Middle Cretaceous to Upper Eocene time.

CENOZOIC ERA

The Laramide Revolution caused rapid denudation of the land mass. Early Teriary sediments, of Eocene age, were rapidly accumulated in deltas and lake basins. The Puget Group was deposited in the delta of the ancestral Fraser River; while the Coldwater Group of coarser clastics were laid down in lake basins eroded in the underlying Cretaceous rocks. Volcanic activity continued through the Eocene epoch and at least into Lower Miocene time.

At the close of the Miocene epoch re-elevation of the land mass occurred, as indicated by an unconformity between the Coldwater beds and the overlying beds of the Tranquille Group of early Lower Miocene age. Sedimentation during the Miocene epoch was apparently much the same as in Eocene time, the clastics being

generally coarse, though with some shale, and intercalated beds of volcanic agglomerate.

The close of early Lower Miocene time marked a great increase in volcanic activity; and during Lower Miocene time some 2000 feet or more of basaltic and andesitic lava flows and agglomeratic beds were laid down in depressions of the Oligocene erosion surface. These volcanics are represented by the Kamloops Volcanic Group.

Possibly in Middle Miocene time further warping produced broad and shallow synclinal and anticlinal folding in the Kamloops Volcanic Group. This was accompanied by minor igneous intrusions and extrusions, and was followed by a long period of erosion, p robably extending into and throughout the Pliocene epoch. During this time the land mass was worn down to a peneplain, the evidence of which is now seen in the flat topped hills of the Interior Plateau. Further regional uplift may have taken place at the close of the Pliocene epoch, and it is probable that considerable faulting occurred at this time on the eastern flank of the Coast Mountains, along the present course of the Fraser River. This uplift of the Interior Plateau caused a marked rejuvenation of the major

streams and rivers. The rivers became entrenched in the canyon-like courses we see today along the Fraser and Thompson Rivers.

At the close of the Pliocene epoch the topography of the Kamloops-Lytton area was probably much the same as it is today. During Pleistocene time the region became cold; and the Cordilleran ice sheet spread over the whole of British Columbia. When the glaciers retreated they left much fluvioglacial material in the old stream valleys. New streams followed these old river channels and cut deeply into this glacial material indicating further regional uplift. This uplift may still be in progress, as the writer saw evidence of recent land slides along the trace of the Siska Creek Fault.

ECONOMIC GEOLOGY

ABSTRACT

At the present time this area is of slight importance to the mining industry. Placer gold has in the past yielded more value than other minerals, and will likely continue to do so. Placer mining is today carried out on a small scale.

Large deposits of coal and lignite occur in the Hat Creek district but are of too low a grade to at present attract investment. Deposits of epsomite and sodium carbonate near Spences Bridge are small, and are intermittently worked.

Some gold prospects have yielded fair assays; and it is probable that development work will be carried out along Cayoosh Creek in particular. It is of interest to note that these gold prospects are confined to the Permian? phyllite and schist. Several occurrences of copper minerals have been found in shear zones in the batholith intrusions of granodiorite. So far these are of no importance, though good deposits may be found in the future. Some deposits of stibnite and molybdenite have been found in the gold bearing Permian? rocks, but nothing of commercial value.

PLACER DEPOSITS

Gold

In 1857 placer gold was discovered in the gravel bars of the Fraser and Thompson Rivers. This discovery precipitated a rush for gold in the area, and resulted in the discovery of many rich deposits. The following year gold was discovered in the gravels of Bridge River. Curiously enough, it was not until 1886 that gold was found in Cayoosh Creek, west of Lillooet. During these early years the most systematic mining seems to have been done by the Chinese. In Cayoosh Creek, during the period 1886-90 the Chinese mined gold to the value of more than $150,000 according to Dawson (1894). On Bridge River, in 1886, a dozen Chinese are reported to have earned $66,000.

Since then placer mining has been carried on steadily, though in varying degrees. During the years of depression following 1929 placer mining received an impetus, due no doubt to the lack of other work, to the encouragement offered placer miners by the British Columbia Chamber of Mines, and to the increased market value of gold. In the past few years placer mining has received very desultory attention. Interest seems to be reviving, however, though mining is still on a small

scale.

Along the Fraser and Thompson Rivers placer mining is confined, for the most part to the working of gravel and sand bars and low benches a few feet above water level. In only a few places have the higher bench gravels been mined, because of the excessive amount of overburden, and the lack of water. Washing methods commonly employ various styles of sluice boxes, with some rockers being used. The gold varies in size from very fine dust to small flakes of a few cents each in value. Coarser gold is not often found.

Along Cayoosh Creek, a swiftly flowing mountain stream, placer mining is being carried out along a stretch from two to five miles above the confluence of Seton and Cayoosh Creeks. Coarse gold is taken from gravels in the stream bed. Bars are mined at low water, and the creek bottom itself where the water can be diverted.

The source of gold in Cayoosh Creek is most probably the auriferous Permian? phyllite and schist through which the creek flows. Rough pieces of gold with adhering fragments of quartz have been mined from the gravels. The sources of placer gold in the Fraser and Thompson Rivers are not known for certain. Dawson

(1894) found traces of gold in Tertiary conglomerates, but none in conglomerates of Cretaceous age. The gold may in large part come directly from the re-sorted fluvioglacial material.

LODE DEPOSITS

Gold

About twelve miles south of Ashcroft, on the west side of the Thompson River, a property previously owned by Martel Gold Mines, Ltd. was intermittently worked between the years 1934- 39. A total of 1,035 feet of drifting, cross cutting and sinking was done, according to Duffell (1946). Values in gold were found in lenticular quartz veins in folded slates of Permian? age.

In the south west corner of the Ashcroft Sheet, near Pyramid Mountain, about twelve miles south west of Lytton, gold values are reported by McTaggart (1946). These occur in quartz veins which are often parallel to the schistosity of the Permian? phyllite and schist which constitutes most of the country rock. This area is accessible only by means of rough trails; and developement work has consequently been negligible.

West of Lillooet, along Cayoosh Creek, a good deal of prospecting has been carried out in lenticular quartz veins in the folded schists of Permian? age. Coarse gold has been found about eight miles up the creek from Lillooet; but as yet only a few feet of tunnelling has been done.

Copper

Some 25 miles south east of Ashcroft, in a batholith of granodiorite, the O.K. Mine and Kathleen Claim are situated. During the years 1914-18 some 10,000 tons of ore were mined from the former location (Duffell, 1946). This ore occurred in a fault zone in the granodiorite. The minerals, mostly chalcopyrite with some chalcocite were in a gangue of quartz, associated with much sericitized wall rock. The granodiorite is considered to be Jurassic or later in age.

Between Laluwissin and McGillivray Creeks, on the east side of Fraser River, about 20 miles north of Lytton, the writer noted a very minor deposit of chalcocite in a shear zone in the granodiorite batholith. This chalcocite is associated with quartz in a rusty, weathered zone. Tunnelling and open cutting have been carried out only to the extent of a few feet. No chalcopyrite has been found.

Molybdenum

Some molybdenite was mined by the Martel Gold Mines, Ltd., but not in sufficient quantity to be marketable. No other deposits have been found.

Antimony

In the south west corner of the Ashcroft Sheet, near Skihist Mountain, stibnite occurs with quartz in a shear zone. This shear zone is more or less parallel with the contact between Jurassic phyllite and intrusive granodiorite. No developement work has been done, probably because of the relative inaccessibility of the location.

Iron

On the west side of Thompson River, near its confluence with Nicola River, a deposit of hematite occurs in a shear zone cutting a batholith of granodiorite. The hematiteis in the form of stringers and as the matrix in a fault breccia. Very little developement work has been done; and it is doubtful if the deposit is of commercial value.

Jade

Between Pyramid and Akasik Mountains in the Coast Mountains, about 10 miles south west of Lytton, there occurs a serpentinized zone in which jade of gem

quality has been mined. Most of the jade is pale green and mottled milky white in color, though some translucent deep green pieces have been obtained. During the summer of 1946 small scale 'pocket' mining was carried out and jade of gem quality was marketed in Vancouver.

SEDIMENTARY DEPOSITS

Epsomite

About eight miles south west of Ashcroft and two miles west of the Thompson River is located the Basque epsomite deposit. This deposit of high grade magnesium sulphate occurs in four small ponds. According to Gouge (1924) there were 75,000 tons of salts available in the four ponds. Duffell (1946) states that since then some 3,000 tons have been removed, and that the latest production in 1942 amounted to 45 tons of technical salts and 20 tons of medicinal salts.

Sodium carbonate

During the summer months, sodium carbonate is mined from the salt encrusted mud flats of Soap Lake, some two miles south of Spence Bridge. The deposit is of little commercial value.

Lignite

Along Hat Creek outcrops of coal and lignite are found in the Tertiary sediments. These cover a wide area but are, according to MacKay (1925), of poor quality. The deposits are easily accessible by road; yet only desultory developement work has been carried out. Because of their poor grade, these coals are probably of little commercial value.

CLASTIC DEPOSITS

Sand and Gravel

Large fluvio-glacial deposits of sand and gravel are to be found in many places along the Fraser and Thompson Rivers. These are usually easily accessible on old river benches and glacial deposits in the valleys. A clean, well sorted sand is quarried near the mouth of Botanie Creek and used locally in making cement. Large beds of well sorted gravel and sand are to be found along the river terraces at Lillooet; and some gravel has been quarried there.

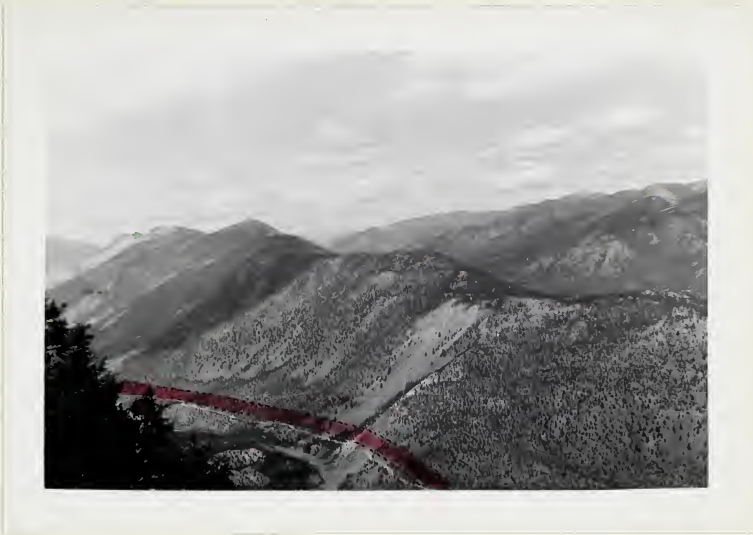
PART 3

GEOLOGY OF THE LILLOOET AREA

FOUNTAIN RIDGE

General View of South End

PLATE 10



View looking north-west across Fraser Valley from a point opposite the mouth of Cinquefoil Creek, on the lower slope of Askom Mountain.

Note the sill-like intrusion of diorite cutting the Lillooet Formation. Rounded slopes at the southern end of Fountain Ridge are characteristic of the erosion of argillaceous rocks. The rugged topography of the northern end of the ridge, which is largely composed of arkosic rock, can be seen in the distance.

In the right background are the Tertiary? and Lower Cretaceous volcanics, forming the western fringe of the Interior Plateau.

TABLE OF FORMATIONS, LILLOOET AREA

Period	Epoch	Stage		App. Thickness	Description of Beds
Tertiary?	Oligocene?			Several hundred feet	vesicular basalt,
	Low. Cretaceous	Aptian?	Fountain Ridge Formation	2000 plus ft.?	andesites, basalts, tuffs, agglomerates, some interbedded conglomerate and arenaceous sediments
				4800 plus ft.	conglomerate, arkose, minor argillite, graywacke, in part tuffaceous
		Barremian	Lillooet Formation	2500 ft.	argillites, tuffs, minor arkose
Permian?			Chilliwack Group	5000 ft.?	phyllite, schist, cherty argillite, minor limestone, basic volcanics

STRATIGRAPHY

PREVIOUS WORK

No previous detailed study has been made of Fountain Ridge. Dr. G. M. Dawson during the years 1877-94 made reconnaissance surveys in the Kamloops area and came to some general, though astute conclusions as to the stratigraphy and structure of Fountain Ridge. Dawson (1894) in referring to the Lillooet area stated, "if a complete section could be reconstructed, the Cretaceous rocks would be found to possess in the aggregate a volume approaching 10,000 feet". The writer estimated over 7,000 feet of sediments in Fountain Ridge.

Extending north-west from Fountain Ridge to Chilko Lake the belt of Lower Cretaceous rocks widens considerably, and several persons have studied these rocks, notably along Bridge River.

Some seventy-five miles north west of Lillooet, Bateman (1912) describes 15,000 to 20,000 feet of sediments conformably underlain by at least 10,000 feet of volcanics. These beds he believed to be of Lower Cretaceous age. The lower section consists of porphyritic andesite, breccia and tuff; the upper section

of conglomerate, arkose, laminated argillites and siltstone, and some limestone. From the upper beds of the upper section Bateman collected the following fossils:

Aucella crassicollis (Keyserling)
Aucella piochii (Gabb)
Aucella pallasi (Keyserling)
Belemnites impressus (Gabb)
Terebratula sp.

Bateman believed this fauna to have affinities with that of the Shasta Series in California. Bateman's section for the upper series above the volcanics is as follows:

> Several thousand feet of alternate beds of dense, black argillite and greenish arkose, with a few thin beds of crystalline limestone in the argillites.
>
> ------------------------------
>
> Dense, grey to black argillite with some sandy beds and intercalated andesite flows
>
> ------------------------------
>
> Massive beds of indurated, greenish-grey arkose composed of angular fragments of quartz and feldspar
>
> ------------------------------
>
> Conglomerate of well rounded pebbles of cherty quartzite and andesite in a matrix of quartz and feldspar fragments, app. 500 feet thick

Bateman (1912)# describes identically the same section in the vicinity of Eldorado Creek northwest of Lillooet. Here he collected the following fossils, as identified by Dr. T. W. Stanton:

Aucella crassicollis (Keyserling)
Aucella pallasi (")
Aucella piochii (Gabb)
Belemnites impressus (Gabb)
Terebratula sp.
Gastropods
Hexacoralla

Dr. Stanton considered these fossils to be similar to the fauna of the Knoxville Series of California, and also to the Aucella bearing beds of Alaska. The Knoxville Series are now known to be of Upper Jurassic age.

Some thirty to forty miles north west of Lillooet, and west of the Camelsfoot Mountains, MacKenzie (1920) has described the Eldorado Series as consisting of more than 10,000 feet of conglomerate, sandstone, shale and some limestone. He believed this series to be of Lower Cretaceous, age and to lie conformably on the Cadwallader Series of Jurassic age. The Cadwallader Series comprises a great thickness of metamorphosed sedimentary and volcanic rocks.

MacKenzie collected the following fossils from the uppermost section of the Eldorado Series at Spruce Lake:

Aucella crassicollis (Keyserling)
Belemnites sp.
Ammonites

Dolmage (1924) found in the vicinity of Chilko Lake, some eighty miles north west of Lillooet, a series of beds of conglomerate, arkose and shale which he correlated with the Eldorado Series on Bridge River. In these beds he found *Aucella crassicollis*.

The Eldorado Series is possibly a correlative of the strata described by Bateman (1912).

Cairnes (1937) describes the Hurley Formation on Bridge River as consisting of banded calcareous, argillaceous and tuffaceous sediments. He considered this formation to be a correlative of the Eldorado Series, of Lower Cretaceous and possibly, in part, of Upper Jurassic age. From the Hurley Formation he collected abundant crinoid stems, a few molluscs, bryozoa, algae (possibly of the genus *Pachytheca*) and several varieties of gastropods.

Dawson (1894) in referring to the rocks of Fountain Ridge said, "it may be stated that the blackish sandstones, quartzites and argillites form the mass of the lower part of the formation, while the greenish and grey sandstones and quartzites, with the conglomerates, characterize its upper parts". In this general observation Dawson was correct. The writer has given the name Lillooet Formation to this lower section, and

the name Fountain Ridge Formation to the upper section. With regards to the thickness of the section exposed at Fountain Ridge, Dawson (1894) stated "it must exceed 7,000 feet, while it is very probable 10,000 feet or more".

FOSSIL LOCALITIES

F1 --- The fossils were obtained from massive beds of laminated, bluish-grey arkose and siltstone underlying by a few hundred feet the Jackass Mountain conglomerate.

F2 --- The fossils were obtained from a lense of coquina, one foot thick, in a bed of dark grey siltstone. This siltstone is interbedded with a greenish-grey arkose containing several bands, 6 inches to 2 feet in thickness, of a pebble conglomerate. The pebbles vary from 1/4 inch to 1 inch in diameter, and are mainly of quartzite.

F3 --- The fossil was obtained from a massive bed of rusty, bluish siltstone. The bed has been markedly sheared.

F4 --- This fossil apparently came from massive beds of argillite and siltstone which underlie, by a few hundred feet, the beds at F1.

F5, 6 - The fossils were obtained from a lense of coquina, a foot and less in thickness, in a bed of dark grey argillite. This argillite is interbedded with siltstone and minor beds of arkose. These beds are intruded by dykes and sills of diorite (see Slide #30).

F7 --- These fossils were obtained from a bed of siltstone, several feet thick, interbedded with arkose. Approximately 100 feet stratigraphically above this fossil zone is a lense of conglomerate in the arkose. The pebbles, averaging less than an inch in diameter, are of quartzite and igneous rock.

F8 --- These fossils were obtained from a boulder of thinly laminated siltstone and argillite, presumably from adjacent highly folded beds of laminated argillite, siltstone and sandstone. These beds are intruded by dykes and sills of diorite.

F9 --- These fossils were obtained from a bed of laminated argillite and siltstone, interbedded with arkose. Approximately 100 feet stratigraphically above this fossil zone plant remains were found in a bed of arkose.

F10 -- This fossil was obtained from a massive bed of argillite and siltstone. A fossil fern (Cladophlebis? sp.) was also found here.

F11 -- These fossils were obtained from a bed of bluish arkose. Plant remains were also found here. This arkose immediately underlies a bed of conglomerate approximately 20 feet thick. The pebbles in this conglomerate average 1 inch to 2 inches in diameter and are mainly of igneous rock and quartzite.

F12 -- These fossils were obtained from a massive bed of bluish graywacke, underlain by interbedded siltstone and argillite. Plant remains were also found in this arkose.

F13 -- These fossils were obtained from interbedded, dark, grey siltstone and bluish arkose.

F14, 15 These fossils were obtained from interbedded siltstone and arkose.

F16 -- These fossils were obtained from interbedded siltstone and arkose overlain by 200 plus feet of gritstone (a very coarse arkose).

F17 -- These fossils were obtained from a bed of argillite, interbedded with siltstone and arkose,

stratigraphically 200 to 300 feet below the fossil zone at F11.

F18 -- These beds are in general interbedded argillite, siltstone and arkose, in part highly folded, and intruded by dykes and sills of diorite and aplite.

F19 -- These beds are in general interbedded dark grey siltstone and bluish argillite.

F20, 21 These beds are in general interbedded argillite, siltstone and arkose.

Premliminary Report on Collections Made by K.C. McTaggart from the West Half of the Ashcroft Sheet, in 1946.

Submitted by F. H. McLearn

F1. One quarter mile south of Siwash Creek Bridge on main highway, along Fraser.

Pecten (Entolium) sp.
Pleuromya sp.
'Shasticrioceras ? sp.
'Terebratella' cf. whiteana Anderson

The specimen of 'Shasticrioceras' is too small for positive identification.

The age is probably Lower Cretaceous.

F2. Rock slide just east of highway, just south of south edge of sheet.

Pleurotomaria ? sp.
Pleuromya sp.
Trigonia sp.
'Acrioceras' ? sp.
'Belemnites' sp.

Although there are many specimens in this collection few are good enough for identification and dating. I think, however, the age is Lower Cretaceous.

F3. At south edge of sheet, on highway, between Boston Bar and Lytton.

Indeterminate ammonite

All that can be said about this specimen is that it is a fairly large moderately involute, ribbed am-

monite.

F4. Float, from Siwash Creek. Fragment of an ammonite. This strongly ribbed ammonite may belong to the Lower Cretaceous ammonite genus *Cheloniceras*. However no positive identification is possible.

F5. South end of Fountain Ridge, opposite mouth of Texas Creek, West slope, at elevation of 2000 feet.

Crinoid stems and indeterminate brachiopods.

F6. South end Fountain Ridge, opposite mouth of Texas Creek, on top of ridge.

Indeterminate mold of ammonite fragment.

F7. On hillside, elev. 2000 feet, Fountain Ridge, West slope, 4 miles N.W. along highway from mouth of Texas Creek.

Trigonia sp .
Pecten sp.
Many small immature species of pelecypods.

Nothing here to indicate age. Ornament of *Trigonia* not preserved.

F8. Boulder from Fraser River, near mouth of Int-l- pam Creek.

Aucella sp.

probably of Lower Cretaceous age.

F9. Elevation 4500 feet, Fountain Ridge, 3 miles directly east of Lillooet, west slope.

Lima sp.
small fragment of an ammonite. Sonneratia ?

Age: ?

F10. 1½ miles south of Fountain Station - elev. of 3000 feet.

Indeterminate ammonite.

F11. Very north end of Fountain Ridge, above road - talus

Pleuromya sp.
Pecten sp.

Probably Lower Cretaceous.

F12. One quarter mile from west end of sheet, N.E. side of Bridge River, elev. of 5,000 feet.

Trigonia. (at least 2 species)
'Belemites' sp.

Lower Cretaceous.

F13. One half mile S.E. of F.12 - elev. of 3600 feet.

Pecten sp.
Pleuromya sp.
Nemodon ? sp.
small fragments of ammonite

Lower Cretaceous.

F14. One mile east of edge of sheet, 1 mile north of Bridge River, elev. of 2250 feet.

Pecten sp.

Pleuromya sp.
Nemodon ? sp.
Shasticrioceras sp.
'Belemnites' sp.

The age is Lower Cretaceous and possibly the Barremian stage or middle of the Lower Cretaceous.

F15. In Creek, elev. 2000 feet, 1 mile north of confluence of Fraser and Bridge Rivers.

Indeterminate ammonite.

F16. Fountain Ridge, 1 mile N. 60 degrees east from highway bridge across Fraser River at elev. 2500 feet.

Pleuromya sp.
Nemodon ? sp.

Lower Cretaceous.

F17. On Highway, immediately south of Fountain Station.

Pelecypods

F18. One mile south of Mount Brew on ridge.

Aucella sp.

Lower Cretaceous, probably quite early Lower Cretaceous.

F19. East slope of very north end of Fountain Ridge, at elev. of 2000 feet.

'Shasticrioceras' ? n. sp.

Lower Cretaceous, possibly the Barremian stage.

F20. 200 yds. west of Stein River Bridge

Plant stems.

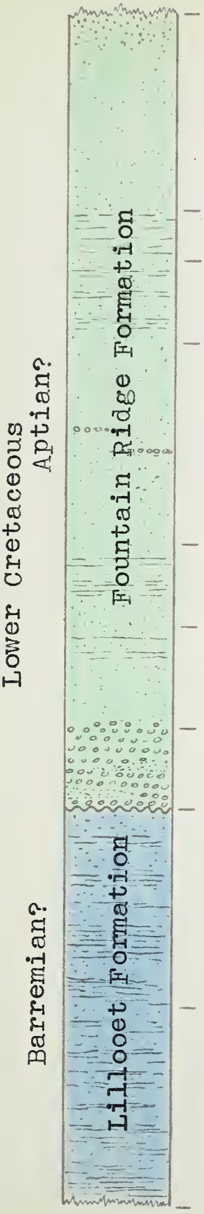
F21. On Botanie Creek Road - just west of 'Crag' Almost 1½ mi. from Lytton.

crushed pelecypods - indeterminate

PLATE 11

STRATIGRAPHIC COLUMN OF FOUNTAIN RIDGE

Scale: 1" to 1000'



A	Grey, feldspathic gritstone, grading downward into bluish-grey arkose and/or graywacke
B	Massive, dark grey argillaceous rock
C	Massive, bluish arkosic rock with beds of argillaceous tuff? varying in thickness from a few inches to four feet
D	Arkosic and tuffaceous graywacke, with lenses of conglomerate varying in thickness from 1-20 feet
E	Graywacke and argillaceous tuff
F	Tuffaceous graywacke, with numerous beds of argillaceous tuff? a few inches in thickness, and arkose in the lower section
G	Massive conglomerate, 300 plus feet thick, with lenses of arkose and arkosic sandstone
H	Massive argillaceous beds with arkosic tuff and tuffaceous graywacke in the upper section; tuffaceous arkose and laminated arkose and calcareous siltstone in the lower section
I	Argillaceous tuff in the upper section; tuffaceous? argillite and minor beds of coquina limestone, a few feet thick, in the lower section

LILLOOET FORMATION

This formation was named by the writer. It consists of massive beds, commonly tuffaceous, of argillites and slates, laminated argillite and siltstone, minor arkose and graywacke, with intercalated beds of argillaceous and arkosic tuffs. The beds are generally steeply folded, and in places show drag folds and overturning. Where they outcrop along the faulted contact with the Palaeozoics the beds are highly folded and partly mashed. It is doubtful that this marked folding is entirely caused by faulting, as the beds appear to be just as highly folded where they outcrop along the Fraser River Bend. Probably an unconformity exists between this formation and the overlying Fountain Ridge Formation; and the more highly folded nature of the beds in the Lillooet Formation can therefore be attributed to their older age. However, it is to be expected that argillaceous beds will more readily fold than will arenaceous beds; so that the beds of the Lillooet Formation may not have been subjected to any more stress than those of the Fountain Ridge Formation.

In some localities where laminated siltstone and argillite occur, the laminae are highly crumpled, evidently from stress applied prior to consolidation,

and possibly during compaction of the sediments. It is likely that the sediments were laid down as near-shore deposits in deep troughs. Under such conditions crumpling could be caused by slumping of the sediments. The only other explanations would seem to be some orogenic stress, or the pressure resulting from the intrusion of a magma into adjacent beds, prior to their consolidation. No evidence of intrusion was seen.

Most fossils were collected in a zone immediately underlying the Fountain Ridge Formation.

FOUNTAIN RIDGE FORMATION

This formation was named by the writer. It probably rests unconformably on the Lillooet Formation. This unconformity is by no means obvious, and may be in the nature of a disconformity in some places. The formation consists of much more arenaceous material than the underlying Lillooet Formation. The basal member is usually a lens shaped bed of conglomerate, plus or minus 300 feet thick, which has been found to rest, apparently unconformably, on beds of argillite, arkose and tuff, depending upon the locality. The basal member is not always conglomerate, but in places is a massive bed of arkose. This is to be expected, as the conglomerate appears to grade laterally into arkose. Twenhofel

(1936) states, "any clastic deposit may be expected to grade laterally into another clastic deposit of some other degree of texture, or into a deposit of different lithology". On this basis of reasoning only a generalized section of Fountain Ridge is here presented; for there are numerous minor differences in the succession at various parts of the ridge.

Above this conglomerate zone the beds consist mainly of massive arkose and graywacke, with minor interbedded siltstone and argillite. Some 2,000 feet stratigraphically above the basal conglomerate zone is another conglomerate zone, the lenses of which vary from 10 feet to 30 feet in thickness. In other beds of arkose are several smaller conglomerate zones, varying in thickness from a few inches to two or three feet.

Where the basal conglomerate zone is some 300 feet thick it has a marked lithological resemblance to the Jackass Mountain conglomerate. The cobbles, averaging three to four inches in diameter are of leucocratic diorite and quartzite, with some cobbles of volcanic rocks, in a matrix of arkose. The other conglomerate zones are lithologically much the same. The uppermost bed of the Fountain Ridge Formation is

of very coarse arkose, or gritstone, which appears to grade laterally into another minor conglomerate zone.

The interpretation of an unconformity between the Lillooet and Fountain Ridge Formations is admittedly based on inconclusive evidence, which is presented as follows:-

1. Although in several localities numerous dykes and sills of diorite, feldspar porphyry and aplite intrude the Lillooet Formation, no intrusions into or above the basal conglomerate zone of the Fountain Ridge Formation were observed.

2. Along the west side of Fountain Ridge, at the base, there extends a sill-like intrusion of diorite. In one locality the basal conglomerate zone appears to lie directly on this sill.

3. The conglomerate zone was found to be directly underlain by argillite in some localities, and by arkose in others. It is possible for arkose beds to grade laterally into argillite. However in one instance this variation occurred within a distance of half a mile, and the field relationships suggested that the conglomerate was unconformably overlying two lithologically distinct beds.

4. The beds of the Lillooet Formation are generally much more highly folded than those of the Fountain Ridge Formation.

5. Although the interpretation is open to argument, it is probable that a bed of conglomerate 300 feet thick is more likely to be interformational than intraformational.

6. As indicated by lithological similarity, this basal conglomerate zone may coincide with that of the Jackass Mountain Group. The writer measured a section on Jackass Mountain which apparently indicated (see Plate 8) an unconformity at the base of the Jackass Mountain Group. It is suggested that a similar unconformity, though apparently not of the same magnitude, may exist at the base of the Fountain Ridge Formation. This interpretation is based on the premise that the Fountain Ridge Formation and the lower part of the Jackass Mountain Group are of the same age. Fossil fauna and flora indicate a Barremian age for the Lillooet Formation and an Aptian age for the Jackass Mountain Group. It is suggested that the Fountain Ridge Formation may also be of Aptian age.

GENERAL CONCLUSIONS

Fossil collections from localities both above and below the base of the Fountain Ridge Formation indicate a Lower Cretaceous age for these beds. Most fossil localities are in a zone just underlying the basal conglomerate of the Fountain Ridge Formation. Certain of these fossils indicate the beds to be possibly of Barremian age. The fossils from F18 were taken from beds presumably equivalent to those of the lowermost part of the Lillooet Formation as they are underlain by granodiorite, and beds of the Chilliwack Group. These indicate an age, according to Dr. F. H. McLearn, "probably quite early Lower Cretaceous". Of the fossils from the Fountain Ridge Formation, no precise age is indicated, other than Lower Cretaceous. If, however, the Fountain Ridge Formation is of the same age as the lower part of the Jackass Mountain Group, it is then probably of Aptian age. It is probable that if an unconformity exists between the Lillooet and Fountain Ridge Formations it possibly represents a period of time during the transition from Barremain to Aptian time.

One fact may not be in accord with this idea, and that is the crystalline nature of the igneous in-

-trusives in the Lillooet Formation. Intrusives of aplite were found; but many dykes and sills are of fairly coarse diorite, which may indicate that intrusion took place at a depth of 5,000 feet or more. In order for the interpretation of an unconformity to be tenable it is necessary to postulate the erosion of some 5,000 feet of sediments during a period inclusive of Barremian and Albian time, and possibly between the Barremian and Aptian stages. However, as the Lower Cretaceous occupied a period of possibly 20,000,000 years, and as the area was probably undergoing orogeny, the hypothesis is not untenable. Furthermore, it is probable that the coarseness of a crystalline rock is not entirely a function of depth; and therefore intrusion may have occurred at much less than a depth of 5,000 feet.

Bateman (1912) described a section of what he believed to be Lower Cretaceous sedimentary rocks, some seventy-five miles north-west of Lillooet. The basal member was a conglomerate, approximately 500 feet thick. This conglomerate may be a correlative of the conglomerate zone at the base of the Fountain Ridge Formation. These conglomerate zones may indicate a marked acceleration of the orogeny, possibly toward the end of Barremian time. It is of interest to note,

in this connection, that Anderson (1938) in referring to a conglomerate member at the base of the Horsetown Group in California states, "In middle Lower Cretaceous time, at the beginning of the Horsetown Group epoch, an uplift occurred in California and Oregon, and possibly along the entire West Coast, including Alaska". The basal section of the Horsetown Group is of Hauterivian age. If Anderson's assumption is correct, there is reason to think that a similar uplift may have resulted in the formation of the conglomerate zones near Lytton, Lillooet and Chilko Lake. In general, the fauna from these latter localities indicates a correlation with that of the Shasta Series. The Fountain Ridge Formation, Lillooet Formation, and the Jackass Mountain Group may be equivalent in age to the Horsetown Group.

A study of thin sections made of clastic rocks taken from various horizons of the Lower Cretaceous succession indicate, by the angularity and poor sorting of the fragments, a rapid accumulation of sediments. The land mass, during Lower Cretaceous time, probably had considerable relief. The sediments may have been deposited in irregular and deep troughs, or may have formed an alluvial plain. Twenhofel (1936) states, "Wedge shaped lenses of gravel, several

hundred feet thick, can be built up in deep off-shore depressions". The conglomerates at the base of the Fountain Ridge Formation may have formed in this manner.

During the greater part of the time, massive beds of sand and mud were deposited, most probable in deep troughs. The crumpled laminae before mentioned were probably caused by slumping of the sediments along the steep gradient of the trough. Twenhofel (1936) further states, "Deposits are functions of the supply and of the depths of the waters, the sediments having wider distribution and lesser thickness the less deep the waters, and less distribution and greater thickness the deeper the waters". The beds of Fountain Ridge may be of this latter type. Although an attempt has been made to correlate them in a general way, individual members cannot be traced laterally for very far. The association of plant remains with the marine fauna indicate that the deposits were laid down very close to shore. Petrographic studies of Fountain Ridge indicate that the rocks supplying the detritus in Lower Cretaceous Time, were igneous, volcanic and sedimentary.

It is probable that the land mass which supplied this detritus lay not far to the west. Phemister

(1945) states, "No Lower Cretaceous sediments are exposed in the vicinity of Vancouver ------- nor do any beds of this age appear to have formed, since the Upper Cretaceous strata rest directly on the Jurassic rocks". This would indicate that the Vancouver area during Lower Cretaceous time was high; and it seems very likely that the erosion of this land mass, which probably extended northward, formed thick deposits in a deep trough along its eastern shore.

STRUCTURE

PREVIOUS WORK

The only previous work on Fountain Ridge was done by G. M. Dawson (1894). Here again, Dawson made some very astute observations, although he states that along the Big Bend of the Fraser River, "although both sides of this part of the river have now been examined, the irregularities found are such that no really satisfactory general section has been obtained". Dawson says, however, "The general structure of Fountain Ridge is that of a syncline, which appears to be simple in its southern part, but becomes wider and more irregular and complicated to the north". In this observation Dawson was correct.

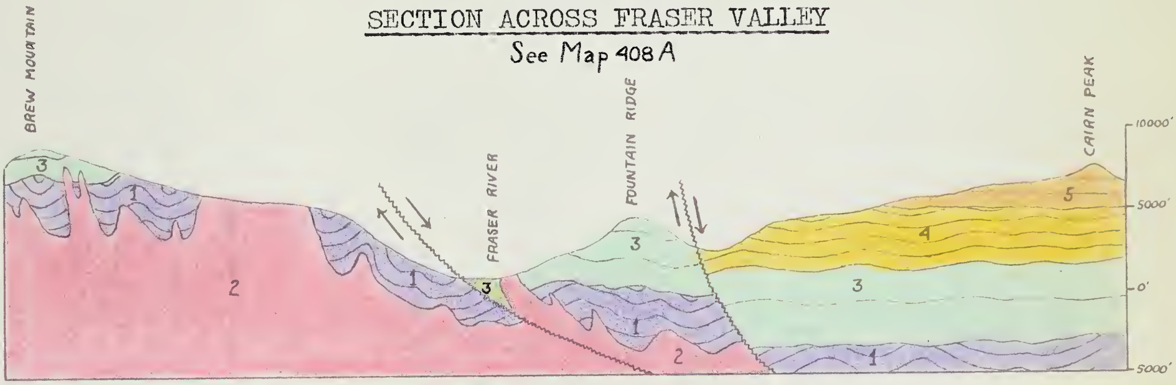
Since Dawson's reconnaissance surveys no work at all has been carried out in the immediate vicinity of Lillooet.

FOUNTAIN VALLEY FAULT

The Fountain Valley Fault extends in a general north-westerly direction along Fountain Valley on the eastern flank of Fountain Ridge. To the south, the fault is continuous with the McGillivray Creek shear zone; to the north, the fault crosses the eastern part

GENERALIZED
SECTION ACROSS FRASER VALLEY

See Map 408 A



Section U-V

TERTIARY ? 5
volcanics 4
LOW. CRETACEOUS 3 arkose, argillite, conglomerate
JURASSIC ? and later 2 granodiorite, etc.
PERMIAN ? 1 phyllite, schist

of the Big Bend and continues in a north-westerly direction across the Camelsfoot Mountains.

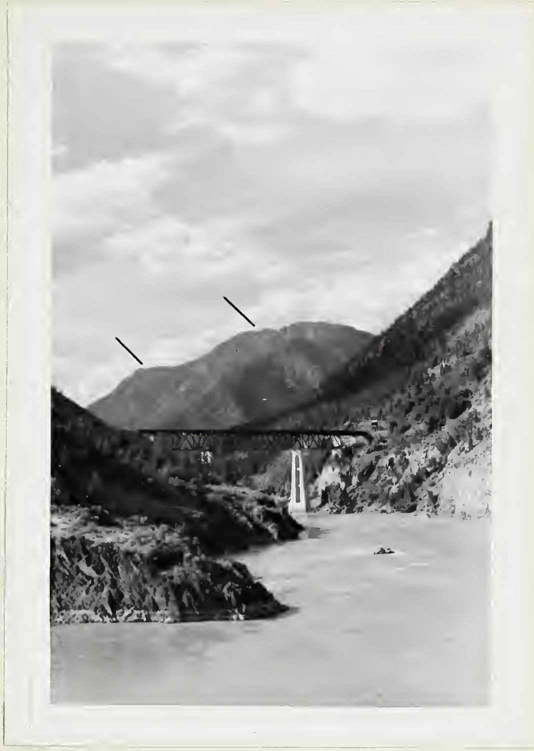
The fault is not exposed in Fountain Valley; but is well exposed along the banks of the Fraser River, where the Lower Cretaceous sedimentary beds, and the volcanics with which they are in faulted contact, are highly folded and smashed. Nowhere, however, did the writer see any distinct contact between the sedimentary and volcanic beds, the fault being marked by a zone of sheared and altered rocks. Dawson (1894) states, "To the east of Fountain Creek, Cretaceous rocks, generally sandstones ----- are not only much shattered and reddened, but also as a rule highly silicified; and in consequence ----- no precise line was discovered between them and the distinctly volcanic rocks -----."

As will be observed from Map No. 1 (Geological Map of Lillooet Area, B.C.) the fault comes to the surface at more or less the same elevation along the Fountain Valley; so that its dip cannot be determined here. Even where the fault crosses Fraser River, its trace at the surface falling some 1500 feet, there was no evidence of a dip either to the east or west. It is

GENERAL VIEW

NORTHWARD EXTENSION OF FOUNTAIN RIDGE

PLATE 13



View looking north from Lillooet highway bridge toward the extension of Fountain Ridge on the north side of the Big Bend of the Fraser River.

Bridge River flows in the valley on the left;Fraser River flows in the valley on the right. Note the uniformity of dip in the Fountain Ridge Formation,as indicated by ruled lines, and the steeply folded beds of the Lillooet Formation forming outcrops along the river.

The bridge in the foreground is the Pacific Great Eastern Railway crossing on the Fraser River.

apparent that the fault has a very steep dip, possibly of approximately 80 degrees to the east. It is probable that this dip decreases at depth, as illustrated in PLATE 12.

The interpretation of a dip to the east was based partly on the dip of the Lillooet Fault, which was reasonably accurately measured as 40 to 45 degrees to the east, and partly on the relationship of the volcanics to the east. Dawson, in his 1877 report supposed these volcanics to constitute an underlying part of the Cretaceous sedimentary beds of Fountain Ridge. In his 1894 report he believed them to overly the sedimentary beds, as he states, "A more detailed examination of the region, in the light of further studies of the formations elsewhere, has since afforded grounds for reversing this opinion". Duffell (1946) has mapped volcanics in the Spence Bridge area, extending north-westerly toward Hat Creek, which he believes to be of Cretaceous age, and probably belonging to the Aptian stage,# as fossils from sandstone beds in these volcanics indicate such an age. The volcanics east of Fountain Ridge probably form a continuous series with those at Spence Bridge, with the possible inclusion of some Tertiary volcanics. The volcanic beds in faulted

#Personal communication

contact with the granodiorite, in the McGillivray Creek shear zone, form identically the same section as found to the east near Spence Bridge. At the former location a greenish agglomerate, possibly two or three hundred feet in thickness, is underlain by granodiorite, and overlain by thirty feet of conglomerate and sandstone. These sediments are conformably overlain by 600 or more feet of basalt, which is columnar in the lower section.

This fault probably is a shear zone of numerous parallel fault planes, having a total width of possibly 1000 feet.

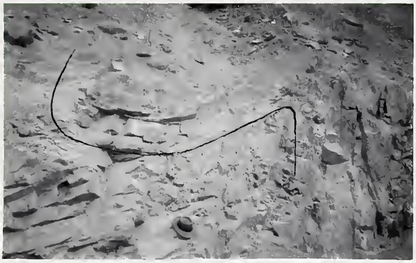
LILLOOET FAULT

The Lillooet Fault, which similar to the Fountain Valley Fault possibly consists of numerous parallel fault planes, passes just to the west of Lillooet, and continues southward along Fraser River. To the north of Lillooet the fault passes through a sharp rise in land (see Map No. 1), thus affording a means of determining its angle of dip. This was estimated to be 40 to 45 degrees to the east. The fault continues in a north-westerly direction along Bridge River.

A ------ Drag fold in argillaceous tuff bed (see Slide 46-00 #24) of the Lillooet Formation.

B ------ Fig. 1 is location of the drag fold above. View looking north-east toward Lillooet Bridge crossing Fraser River. Note the high banks of fluvio-glacial material, forming an alluvial fan at the base of the small valley shown. This fan is now deeply incised by a stream.

PLATE 14



A

B

The contact between the Lower Cretaceous argillaceous rocks and the Permian? phyllite, schists, and greenstones is usually well defined. On the Cretaceous side the rocks are highly folded, overturned folds and drag folds being commonly observed in the argillaceous rocks; while the arenaceous rocks are generally smashed and weathered to a reddish color. The Permian? side of the contact is well marked by a serpentinized zone which is particularly conspicuous to the south of Lillooet. This serpentine has evidently been derived from the shearing and hydrothermal alteration of greenstones which were probably basic volcanics. Bateman (1912)# refers to several hundred feet of andesitic tuffs and breccias, chloritic and serpentinized rocks which he believed to be of Cache Creek age, as occurring north-west of Lillooet along Bridge River. These probably belong to the series here called the Chilliwack Group. At Texas Creek, some twelve miles to the south of Lillooet, an excellent example of a fault breccia is to be seen. This breccia is composed of angular fragments of Cretaceous sandstone in a limonitic matrix.

RELATIONSHIP OF INTRUSIVES

Nowhere was any evidence seen of intrusives in the Fountain Ridge Formation. The Lillooet Forma-

tion, however, is in many localities cut by dykes, and more commonly sills, of diorite, feldspar porphyry and aplite. Dykes and sills, of apparently the same composition intrude the Chilliwack Group. It is not known, however, whether the intrusives in the Cretaceous rocks are of the same age as those in the Permian? rocks; but it is presumed that in part, at least, they are. The intrusives in the Chilliwack Group are partly of the permissive type, as indicated by the gently folded beds of the Chilliwack Group along Cayoosh Creek, and by the lit-par-lit injection into them. In other localities the Chilliwack beds are highly folded and crumpled. It was not possible to determine whether this folding took place during, or prior to the period of intrusion.

The age of these intrusives, into the Lower Cretaceous beds at least, is considered to be Lower Cretaceous, on the grounds of a probable unconformity existing between them and the overlying Lower Cretaceous beds. These intrusives are tentatively, correlated, on lithological evidence in the field only, with those intruding the Chilliwack Group in the Lillooet area. This correlation is by no means certain; nor are the relationships known of these intrusives to the Coast Range igneous bodies. In this respect, Phemister (1945) stated, "On both Vancouver Island and the Queen Char-

-lotte Islands stocks, similar petrographically to the Coast Range bodies, occur cutting rocks of known age, but there must always remain a certain element of doubt as to whether or not these bodies are really contemporaneous with the main batholith".

Measurements of the gneissosity on large intrusive bodies along Fraser Valley indicate a very steep dip to the east. This seems to be a regional trend.

GENERAL CONCLUSIONS

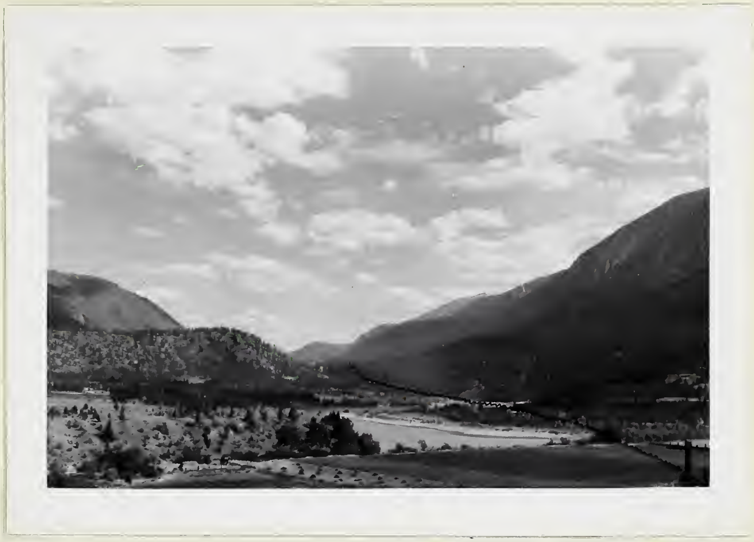
Structurally, Fountain Ridge is synclinal. The southern part forms a simple syncline; the central part has three smaller synclines; and the northern part has two well defined synclines. North of the Big Bend of the Fraser River the structure becomes flatter, with possibly several shallow synclines. The pitch of these synclinal axes is apparently very slight. It was not possible to make any measurements, but on the basis of the generalized cross sections, the plunges are estimated at approximately two degrees. The main syncline plunges to the south; although minor folds apparently plunge to the north.

The main synclinal axis cuts midway across the Big Bend, and here the synclinal structure is clearly seen. Outcrops along the river are generally flat lying; and it is evident that the trough of the syncline, in this locality, is broad and undulating. The exact nature of the eastern flank of the syncline, near the mouth of Fountain Creek, is not known. Some minor, though steep folding was seen; and it is likely that faulting complicates the structure in the vicinity of the contact with the volcanics. To the south, this syncline forms the main structural feature of Fountain Ridge.

Near the confluence of Bridge and Fraser Rivers there is an excellent synclinal exposure, the fold in this locality being very tight. It was not possible to trace this fold for any distance along Bridge River, although to the south the fold is fairly well defined for six or seven miles. It was generally observed that folds could be traced across country by the presence of reddish weathering zones. These reddish zones, in all cases, were in arenaceous beds. It was noted that whereas the argillaceous rocks folded under stress, the interbedded arenacous rocks, being more competent, were smashed and sheared. Caution is needed, however, in using reddish zones to trace folds,

FRASER VALLEY AT LILLOOET

PLATE 15



View from Lillooet,looking south along Fraser River.

The trace of Lillooet fault is marked with a zig-zag line. The hill in the left centre is a moraine. Part of Fountain Ridge can be seen in the left background. The eastern slopes of the Coast Mountains are seen in the right.

as shear zones are also marked by reddish weathered rocks.

It must be emphasized that the geological map (Map No. 1) and the sections A-B to S-T inclusive are generalized. The reconnaissance nature of the field work precluded any more detailed study of the structure. It is probable that the structure of Fountain Ridge is further complicated by minor shear zones.

The Lower Cretaceous? volcanics to the east of Fountain Ridge are in general gently folded to nearly flat lying. The Lower Cretaceous sedimentary rocks to the north of Fountain Ridge become gently folded in the area of the Camelsfoot Mountains. The Permian? rocks to the west of Fountain Ridge are in general highly folded.

On the assumption that the volcanics overlie the lower Cretaceous sedimentary beds, and on the evidence of a dip to the east for the Lillooet Fault, step faulting (see Plate 12) has been postulated to explain the structural relationship of Fountain Ridge. Wedges of Lower Cretaceous rocks are found continuously along Fraser Valley (see Map 408A) where they have probably been relatively preserved from erosion. In some localities these wedges appear to be grabens; while

elsewhere, as at Fountain Ridge, they seem to have been more likely formed by step faulting.

GENERALIZED CROSS SECTIONS
OF
FOUNTAIN RIDGE

(ref.Map No 1)

Legend

Tertiary? and
Lower Cretaceous

6 Volcanics

Lower Cretaceous

5 Fountain Ridge Formation

3 - 4 Intrusives

2 Lillooet Formation

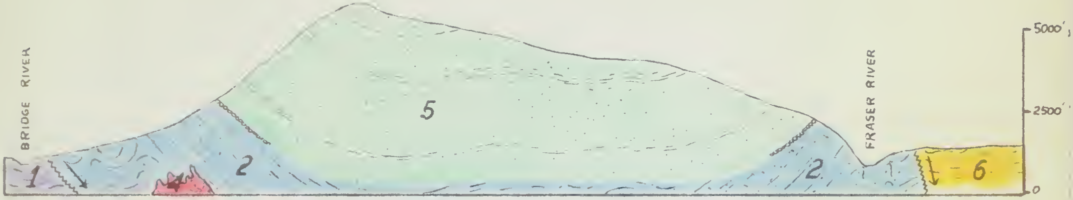
Permian?

1 Chilliwack Group

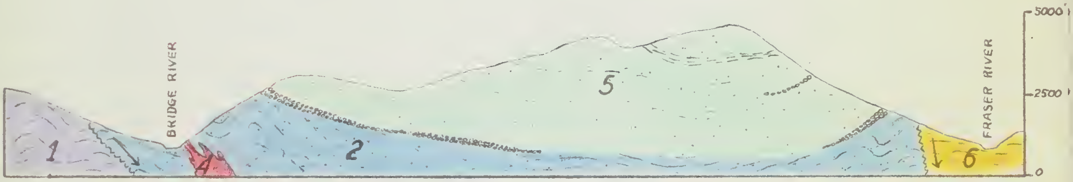
PLATE 16

W

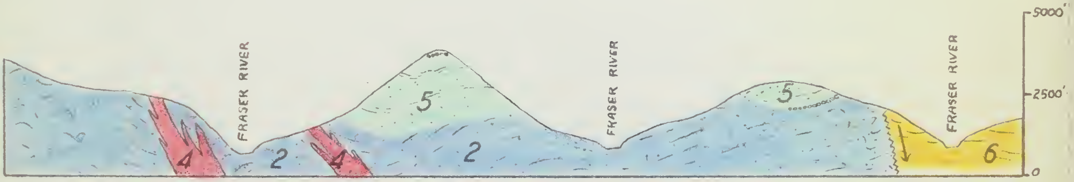
E



Section C- D



Section E-F

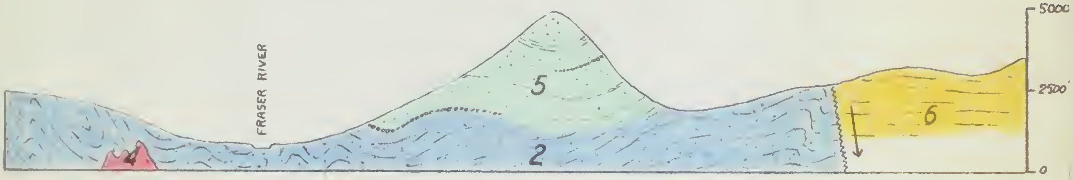


Section G-H

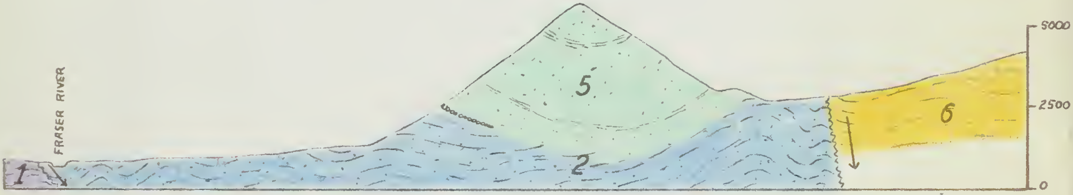
PLATE 17

W

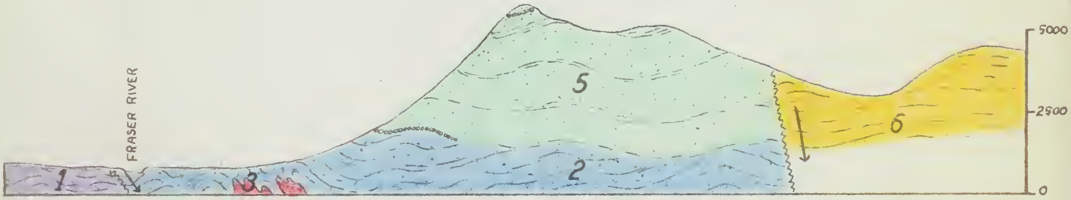
E



Section I-J

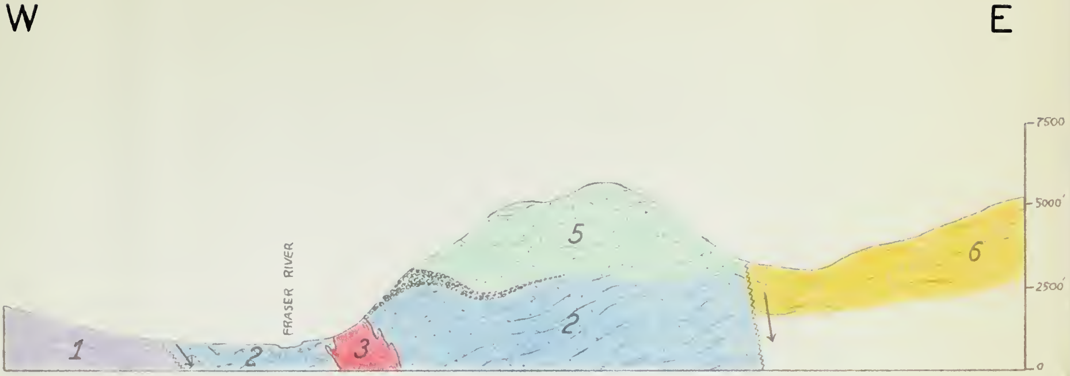


Section K-L

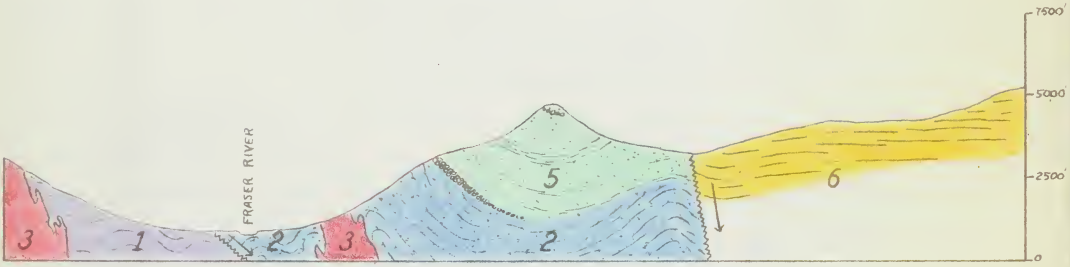


Section M-N

PLATE 18



Section O-P



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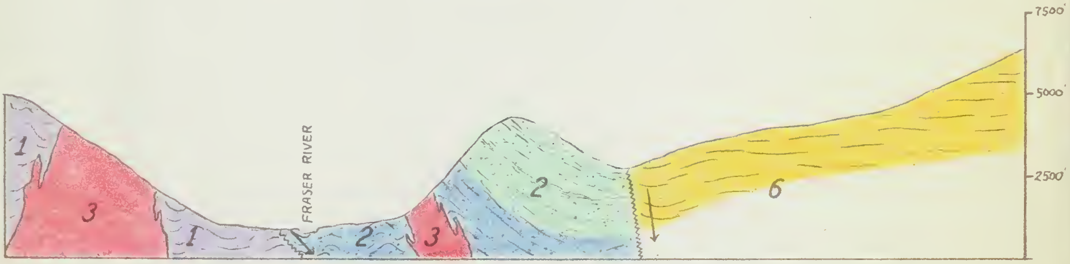

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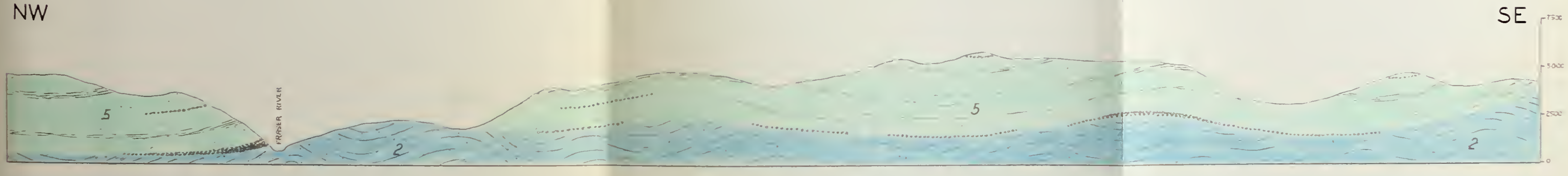


SECTION A-B

GEOMORPHOLOGY

FLUVIO-GLACIAL DEPOSITS

Fluvio-glacial deposits in Fraser Valley are of silts, sand and gravel. In general, the silts overlie the sand and gravel deposits.

Along Fraser Valley the gravel and sand deposits form moraines. There are also alluvial fans which consist largely of boulder clay material, apparently derived from glacial deposits. These alluvial fans are not of recent origin, as present streams are deeply entrenched in them (See Plate 14). It is suggested that they were formed at the close of the glacial period when there must have been a considerable 'run off' from melting snow and ice. Similar material was observed, notably in McGillivray Creek valley, literally choking the valleys adjoining Fraser Valley, and deeply incised by present streams.

Some deposits of sand and gravel were evidently laid down in bodies of water, and probably at steep gradients, as they show folding and faulting which was probably caused by slumping of these sediments. This folding and faulting is plainly seen just north of Lillooet along the cutting of the Pacific

Great Eastern Railway. In places, old stream channels, of Pleistocene age, cut through these glacial deposits. It is evident that most of the glacial deposits were well sorted by water from the melting ice.

The silts, forming deposits a hundred and more feet thick, are difficult to explain. In general they overlie the coarser material, and seem to be lake deposits. It is quite likely that at the close of the Pleistocene epoch moraines and ice blocks in places dammed Fraser Valley, resulting in the formation of long lakes in which were deposited the fine material which now form the silts.

PERMAFROST

Directly east of Lillooet, at the base of Fountain Ridge, a local resident has driven a tunnel through glacial material, some seventy-five feet into the hillside, the end of the tunnel being approximately forty feet from ground level. This tunnel is a local curiosity by reason of the fact that it is a natural refrigerator, ice being formed at the end of the tunnel even in the hottest weather. Indeed, it is claimed that more ice is formed in hot weather than in cold. The tunnel is completely dry, and the ice apparently forms by the freezing of water vapor in the air. This

may explain the fact that more ice is formed in hot weather than in cold, the warmer air probably causing an increased draft through the tunnel, and supplying a greater quantity of moisture. The curious feature is that ice should form at all. Permafrost is not to be expected in Fraser Valley, yet the fact remains, that in this location at least, the ground is at present permanently frozen. It is not implied, however, that permafrost exists, or is to be expected in the glacial deposits of Fraser Valley.

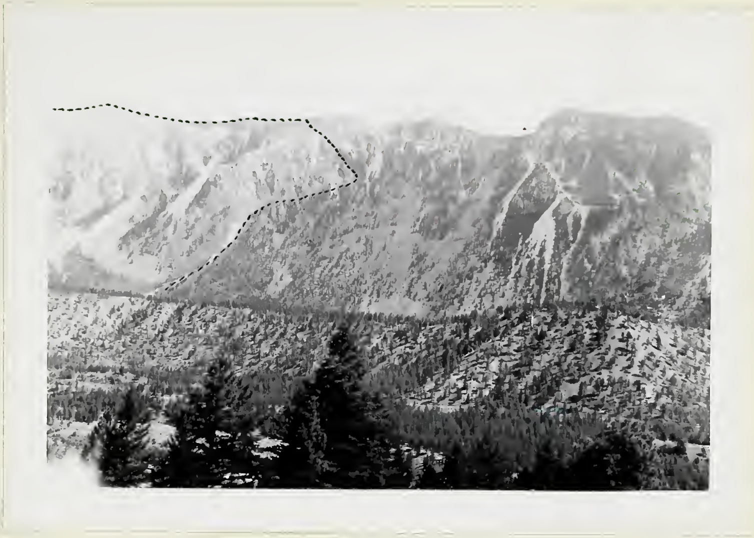
EROSION OF FOUNTAIN RIDGE

Fountain Ridge is rapidly being eroded away on the west flank. This precipitous face is continually subjected to landslides, the writer observing two small slides in the space of a month. Wide fissures, several feet across, extend along the cliff tops, eventually resulting in the falling away of great blocks. Several very large blocks have slid off the face, and are shown in Plate 20. These blocks are so large that their nature is only perceived from a distance; and they consequently introduced an error in stratigraphic calculations when first traversed. Some idea of the rapidity of erosion is indicated by the fact that the top of the ridge shown in Plate 20 is no more than two feet

A ------ View of Fountain Ridge from two miles south of Lillooet, looking east. The dotted line marks the path of ascent made by the writer. Note the numerous talus slides. Erosion of this western slope is very rapid. The hill at the base of the ridge is a glacial moraine in Fraser Valley.

B ------ View of Fountain Ridge, from two miles south of Lillooet, looking south-east. Note the triangular shaped blocks which have slid off the cliffs. The hills at the base of the ridge are moraines.

PLATE 20



A

B

wide, and slopes away at a 30 degree angle from the horizontal on the other side.

BIG BEND OF FRASER RIVER

The Big Bend of the Fraser River is the double-U bend situated some four miles north-east of Lillooet, and directly east of the confluence of Fraser and Bridge Rivers. The Big Bend geographically defines the northern end of Fountain Ridge.

The Fraser River here cuts directly across the formations of Fountain Ridge, and its course is evidently antecedent to the present height of land. The course of Fraser River at the Big Bend has apparently been controlled by the induration and structure of the beds through which the river has cut. The present course is within the Lillooet Formation.

GEOLOGICAL HISTORY

GENERAL CONLUSIONS

In the Lillooet area the earliest rocks known as mainly quartz-mica and chloritic schists, crumpled phyllite with thin bands of crystalline limestone, and intercalated beds of serpentinized greenstone. These beds have been correlated by the writer with the Chilliwack Group, of Pennsylvanian or Permian age, in the southern part of the Ashcroft sheet. They have also been referred to by Dawson (1894) and Bateman (1912)# as belonging to the Cache Creek Series, the upper section of which has been shown by Crockford and Warren (1935) to be of Middle Permian age. The writer is therefore uncertain as to the age of these beds, no fossils having been found, and tentatively considers them to be of Permian age.

No rocks of Jurassic age were found in the Lillooet area. However, some thirty-five miles north-west of Lillooet, MacKenzie (1920) describes Jurassic rocks underlying the Eldorado Series of Lower Cretaceous age. Cairnes (1937) describes the Hurley Formation along Bridge River, some fifty miles north-west of Lillooet, as probably being of Lower Cretaceous, and possibly in part of Upper Jurassic age. It should be

emphasized that no sharp demarcation can be made between rocks of Upper Jurassic and/or Lower Cretaceous ages along Fraser Valley; and it is probable that more or less continuous sedimentation was effected during the transition from one period to the other.

The rocks of Fountain Ridge, and its northward extension, are of Lower Cretaceous age, the lower section possibly belonging to the Barremian stage. The writer considers that the upper section may be of Aptian age. The overlying volcanics are considered by Dr. S. Duffell (1946)# to be, at least in part, of Aptian age.

With the exception of some possibly Tertiary volcanics, no rocks of any other periods are known in the Lillooet area.

The Chilliwack Group as a whole consists of highly metamorphosed argillaceous, arenaceous and volcanic rocks. The argillaceous types are now represented by phyllites, and the arenaceous and volcanic types by schists and greenstones respectively. It is likely that the sedimentary beds were near shore deposits. The volcanics may have been sub-marine, although there is no evidence of this, except the indirect and probable evidence of a sinking landmass as indicated by the overlying Middle Permian limestones near Pavilion Lake.

This is based on the assumption, however, that similar limestone overlay the present sediments of the Chilliwack Group, in the Lillooet area. This assumption is probably tenable, as crystalline limestone occurs with the phyllite, and lithologically similar rocks to those of the Chilliwack Group are found underlying the Permian limestones in the Kamloops area. As previously mentioned, the upper section of the Cache Creek Series is probably over 8,000 feet thick; while the lower section, which the writer is tentatively correlating with the Chilliwack Group probably exceeds 5,000 feet in thickness.

During Triassic time the Lillooet area was apparently high, as no Triassic beds have as yet been found. In adjacent areas the Nicola Group, probably of Upper Triassic age, was laid down. These beds are argillaceous, arenaceous and limy, with a considerable amount of intercalated volcanics.

During Lower Jurassic time the land was generally high, as no beds definitely of this age have been found; although MacKenzie (1920) placed the upper part of the Cadwallader Series, some thirty-five miles north west of Lillooet, as tentatively of Lower Jurassic age.

During Middle and Upper Jurassic times the area was generally inundated, although certain areas were probably high. No Jurassic beds have been found in the immediate area of Lillooet, and the writer has therefore tentatively assumed that the Lower Cretaceous beds rest directly on the Chilliwack Group. In the Hope area Camsell (1919) found presumably Lower Cretaceous conglomerate resting unconformably on slates which Cairnes (1943) has placed as of Chilliwack Group age and younger.

It is generally considered that the orogeny of the Coast Range began in Upper Jurassic time. Undoubtedly, considerably intrusion took place in post-Barremian time, and most likely during the span of Lower Cretaceous time, and this intrusion may have been associated with orogeny. The writer is of the opinion that the orogeny of the Coast Range took place over a long span of time, possibly beginning in Upper Jurassic time and continuing to post-Oligocene time. During post-Oligocene time the major faulting along Fraser Valley apparently took place, as no Tertiary volcanics are found to the west of the shear zone. It is possible, of course, that Tertiary volcanics would have been eroded off the Coast Mountains. This orogeny, over such a

long span of time, was possibly not a continuous uplift, but a series of uplifts.

Troughs of deposition in Lower Cretaceous time were probably deep and narrow, and the topography evidently rugged, as indicated by the general coarseness and poor sorting of the clastic sediments, especially in those deposited during, or possibly in post-Barremian time.

The orogeny of the Coast Range seems to have been one of general regional uplift, as indicated by the general accordance of elevation of the peaks, in both north-south and east-west directions. Sedimentary beds of Cretaceous, possibly Jurassic and Permian ages remain as patches in the interior parts of the Coast Mountains, but have largely been eroded away, exposing the batholiths of dioritic rocks. The continued regional uplift of the Coast Range resulted in down faulting, or step faulting of the Jurassic? and Lower Cretaceous rocks along the eastern flank of the Coast Mountains.

LITHOLOGY OF FOUNTAIN RIDGE

ABSTRACT AND INTERPRETATION

The arenaceous (using the term in its textural sense) rocks are generally medium grained, the grain sizes averaging 0.2 - 0.5 mm. in diameter. These have been designated as arkoses and graywacke. The term arkose has been applied where the clastic material is largely feldspathic; and the term graywacke where the fragments are largely of volcanics, and considered to have been derived from the erosion of volcanic beds. There is no clear cut distinction between these types as found at Fountain Ridge. Some of these arenaceous rocks have been designated as tuffaceous, thereby implying that volcanic glass (not derived from the erosion of volcanic beds) forms a part of the rock.

This interpretation is based on the probable presence of shards of volcanic glass, and the general isotropic character of the groundmass, which is taken to indicate (unless there is much chlorite present) a vitric nature. It should be stated that the writer is aware that even the presence of shards does not prove that volcanic dust settled into the sediments from the air, as they could have been derived from the erosion of an ash bed.

Pirsson (1915) recognizes three main types of tuffs, namely; vitric, crystal, and lithic. He states that most tuffs are a mixture of all three. The vitric tuffs are composed of fragments of volcanic glass; the crystal tuffs of fragments of crystals and euhedral crystals; and the lithic tuffs of fragments of volcanic rock. The thin sections of arenaceous rocks examined by the writer certainly contained numerous angular fragments of volcanic rock, such as felsite and volcanic glass. The presence of shards in any quantity is questionable; and the presence of crystals derived from explosions in volcanic vents is, in the writer's opinion, impossible of proof, one way or the other.

Where clastic material is fairly well rounded, the presence of volcanics(ash) would be indicated by the angularity of the volcanic fragments. However, in the case of the arenaceous rocks examined the clastics were in all cases angular, and in most cases poorly sorted as to size. Thus, on this basis, no differentiation as to origin could be made between fragments.

The interpretation, therefore, as to whether these arenaceous rocks are tuffs or tuffaceous (in the sense of the volcanic material having been transported to these sediments by aeolian means) or whether the vol-

-canic material is wholly clastic, depends to a large extent on the field relationships of the beds. In general, the beds of the Lillooet Formation are laminated, differing lithologically, in a vertical direction, within a few feet, and often within a few inches. The beds of the Fountain Ridge Formation, on the other hand, are massive, and little lithological difference can be noted over a stratigraphic section of several hundred feet. On this basis, the writer is of the opinion that whereas there may be several distinct beds of tuff in the Lillooet Formation; tuff beds are a minor feature in the Fountain Ridge Formation. Many beds in the latter formation, however, may have received wind borne volcanic ash, and therefore could be termed tuffaceous. In short, the beds of the Fountain Ridge Formation are essentially of a clastic nature; and in the writer's opinion the majority of volcanic material was derived from the erosion of volcanic beds.

The arenaceous rocks examined were composed essentially of fragments of rock. It is presumed that these fragments of rock were derived from the Chilliwack Group, the igneous rocks of the Coast Range, and very likely Jurassic and Lower Cretaceous sedimentary and volcanic rocks. The detrital material in the probable order of abundance consists of fragments of feldspar,

volcanics (glass, felsite, basalt and rhyolite), argillite (probably including metargillites and phyllites), and quartz. Minor amounts, as detrital material, of calcite, epidote, and biotite were observed. The groundmass was in most cases difficult to distinguish from the fragments, and in all cases was felsitic. This distinction between groundmass and detrital fragments was made difficult, and sometimes impossible by alteration.

In some rocks considerable chlorite formed part of the groundmass. In other rocks the groundmass was partly isotropic, which the writer considered to indicate the presence of partly devitrified volcanic glass. Most of the feldspar showed alteration, in varying degrees, to sericite (in the case of orthoclase) and possibly paragonite (in the case of plagioclase). A white, opaque alteration product of feldspar, which is probably a kaolinite type of mineral was observed in abundance in the felsitic groundmass. In some cases spherulitic chalcedony, in very minor amounts, fills interstices between grains in the rock.

The presence of a considerable amount of chlorite in the groundmass, and of authigenic epidote, indicates hydrothermal alteration. Seriticization of

the feldspar was probably also effected by hydrothermal action. In view of the structural interpretation, which assumes that the Fountain Ridge Formation was at one time overlain by many hundred feet of volcanics, it is not unlikely that the sedimentary rocks should have been subjected to hydrothermal alteration.

The Lillooet Formation represent a much finer phase of sedimentation than the overlying beds. These beds are probably of Barremian age, as indicated by the fauna, and probably represent the off-shore deposits of a land mass of moderate relief. There was evidently considerable vulcanism at this time.

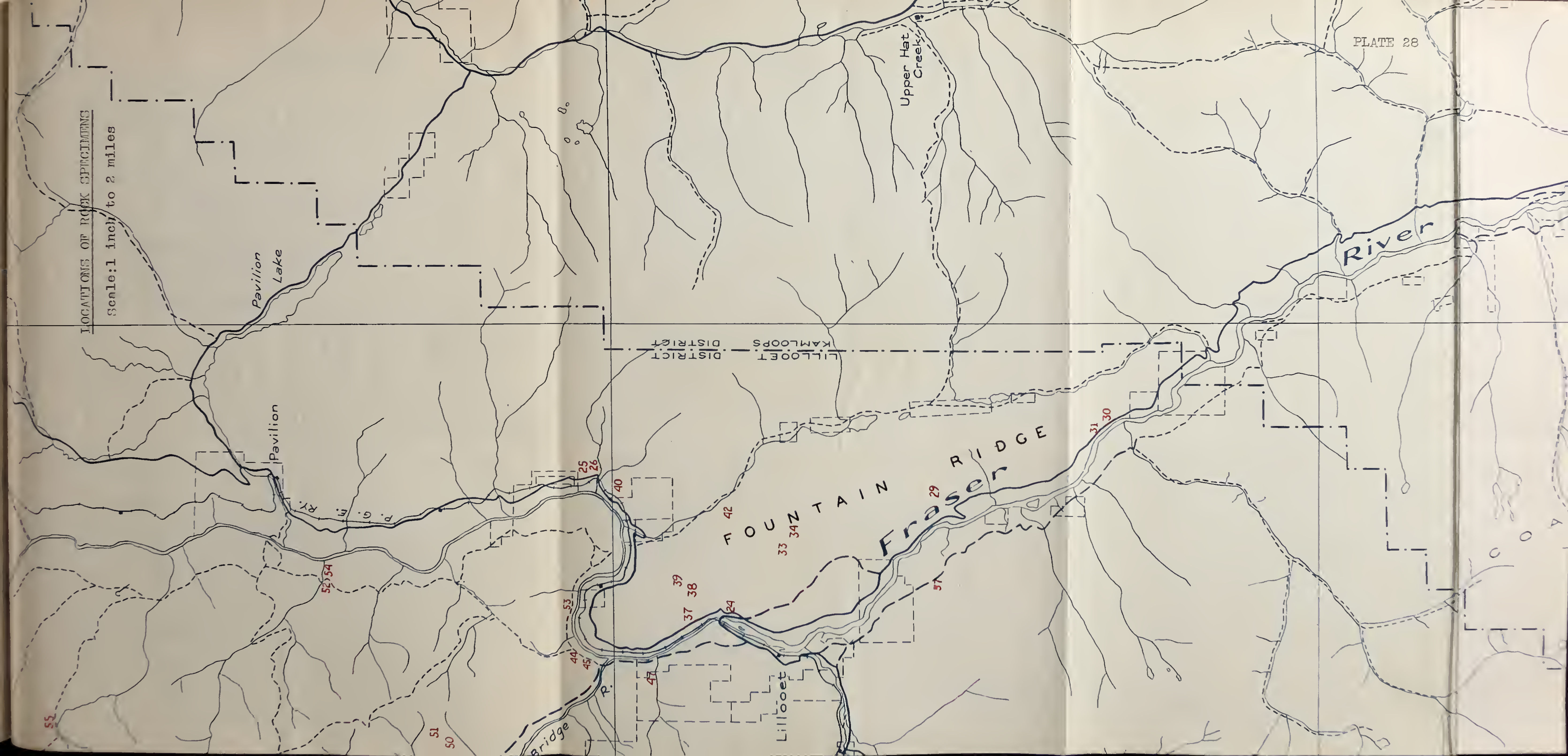
The overlying conglomerate zone may mark a period of accelerated uplift, as previously outlined, or may be a basal conglomerate formed in a sinking trough. At any rate, the land mass was probably rugged, thick and poorly sorted sediments being deposited in deep troughs, or on an alluvial plain. It is evident, from microscopic examination of these clastics, that the material was not carried far, for the fragments are very angular, and usually poorly sorted as to size. During this time vulcanism was again active, though probably not to the same extent as prior to the uplift. Later, however, a great increase of volcanic activity

in Lower Cretaceous, and possibly in Aptian time, resulted in the formation of many hundred feet of volcanic flows and pyroclastics.

The volcanics examined to the east of Fountain Ridge are considered by the writer to be of Lower Cretaceous age, as previously explained. Some of the uppermost beds may, however, be of Tertiary age. The only volcanic of probably Tertiary age examined by the writer was a flat lying flow of fresh, vescicular, olivine basalt occurring in the north-west corner of Map 408 A. This rock is represented by Slide 46-00 #55. The other volcanics were folded, more altered, and consisted of pyroclastics, basalts and minor rhyolite.

The above conclusions reached by the writer are based on the examination of a few specimens from scattered localities, and on the field examination of a stratigraphic section several thousand feet thick and some fifteen to twenty miles in linear extent. It is obvious, therefore, that only very general conclusions were reached.

PLATE 28



LOCATIONS OF ROCK SPECIMENS

Scale:1 inch to 2 miles

LILLOOET FORMATION

Slide 46-00 #47 Section I

Locality

West side of Fraser River, one mile north of Lillooet Bridge.

Field Notes

Specimen from highly folded argillaceous and arkosic beds. Intruded by dykes and sills of feldspar porphyry (Slide #37)

Megascopic Description

Indurated, greyish black, argillaceous rock, weathering brownish.

Microscopic Description

Structure --- indistinct orientation of grains along bedding planes.

Texture ----- fragmental material; fragments average less than 0.05 mm. (measured) in diameter.

Composition (estimated)

70% of the rock is of cryptocrystalline material; felsitic, with carbonaceous matter, minor chlorite and possibly some partly devitrified glass.

30% of the rock is of microcrystalline quartz and feldspar, with minor calcite and pyrite.

Remarks

Fragmental material cannot be distinguished from the groundmass. The rock has been baked by intrusives, and probably hydrothermally altered, though there is no marked evidence of this. The rock has essentially the same composition as Slide #24, though there is no distinct evidence of volcanic material.

Classification

Carbonaceous argillite (possibly tuffaceous)

Age - Lower Cretaceous, possibly Barremian

LILLOOET FORMATION

Slide 46-00 #24 Section I (Upper)

Locality

East end of Lillooet Bridge.

Field Notes

Specimen was taken from a drag-fold in argillaceous beds.

Megascopic Description

Argillaceous rock, grey to blackish, weathering brownish.

Microscopic Description

Structure --- indistinct flaser structure
Texture ------ fragmental material; fragments average less than 0.05 mm. (measured) in diameter.
Composition (estimated)

70% of the rock is cryptocrystalline material; felsitic, with carbonaceous matter, partly devitrified glass and minor chlorite.

30% of the rock is of microcrystalline quartz and feldspar (indeterminate).

Remarks

The rock has been sheared, as a result of folding. This shearing has produced brecciation and an indistinct flaser structure.

Classification

Argillaceous tuff

Age - Lower Cretaceous, possibly Barremian

Slide 46-00 #24 Argillaceous tuff

Using Burton lamp with white ground glass screen. Ansco Supreme film. G(Wratten) filter. Exp. 10 sec. Plain light. Mag.X20.

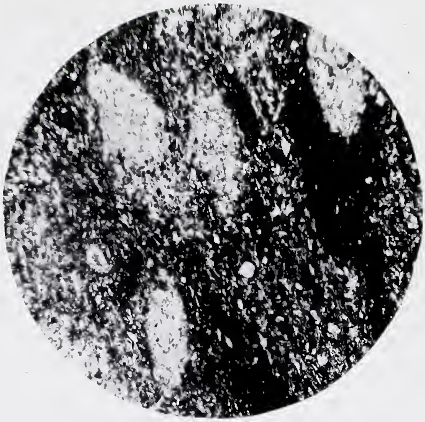
A shear breccia, showing flaser structure. Fragments of cryptocrystalline, tuffaceous rock (light colored) around which have flowed argillaceous material. Specimen taken from a drag fold (see Plate 14).

Slide 46-00 #26 Tuff

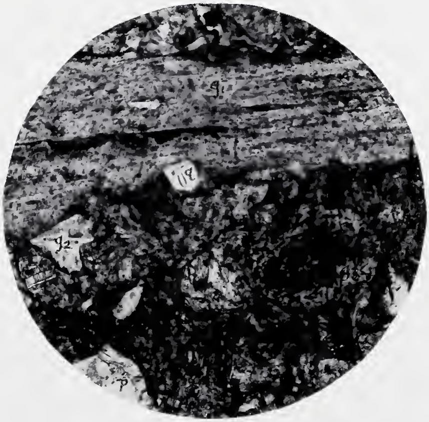
Using Burton lamp with white ground glass screen. Ansco Supreme film. G(Wratten) filter. Exp. 6 sec. Plain light. Mag.X40.

g1 --- flow structure in partly devitrified glass
g2 --- devitrified volcanic glass
g3 --- partly devitrified volcanic glass with inclusions of magnetite
p ---- plagioclase (indeterminate)
q ---- quartz with inclusion of (apatite?)

PLATE 21



Slide 46-00 #24



Slide 46-00 #26

LILLOOET FORMATION

Slide 46-00 #49 Section H (lower)

Locality

West edge of Ashcroft Sheet (408A) and one half mile north of Bridge River.

Field Notes

Specimen from a massive bed containing fragments of argillite, and overlying laminated argillaceous beds.

Megascopic Description

Dark, bluish grey arkose, weathering brownish grey.

Microscopic Description

Texture --- angular, fragmental material; fragments average 0.2 mm. (measured) in diameter.

Composition (estimated)

Detrital	Authigenic
Orthoclase -- 15%	Calcite
Plagioclase - 40%	Pyrite
Quartz ------ 15%	

The matrix, app. 30% of the rock, is of kaolinite?, felsitic material, and cryptocrystalline material which is nearly isotropic and appears to be partly devitrified glass. Feldspars are moderately altered to sericite and paragonite. Plagioclase fragments are of varying composition.

Remarks

The rock is composed of angular fragments of volcanic feldspar porphyry (showing trachytic structure), cherty siltstone, feldspar and quartz. The slide is slightly above normal thickness.

Classification

Tuffaceous arkose

Age - Lower Cretaceous, possibly Barremian

LILLOOET FORMATION

Slide 46-00 #31 Section H (lower)

Locality

South end of Fountain Ridge, on west side.

Field Notes

Specimen from interbedded arkose and siltstone. Intruded by a sill of hornblende quartz-diorite (Slide #30).

Megascopic Description

Laminated, bluish grey arkose and siltstone, weathering brownish grey. (The thin section is of the arkose band.)

Microscopic Description

Texture --- angular, fragmental material; fragments average less than 0.2 mm. in diameter (measured).
Structure - orientation of grains along bedding planes
Composition (estimated)

Detrital		Authigenic	
Orthoclase --	5%	Pyrite	
Plagioclase -	30%	Calcite -	20%
Quartz ------	10%		

The matrix is of calcite, felsitic material, microcrystalline quartz and kaolonite?, constituting app. 35% of the rock. The plagioclase is in part oligoclase and/or albite, as determined by refringence.

Remarks

Feldspars have altered in part to sericite. The calcite appears to have been introduced in irregular patches along bedding planes.

Classification

Laminated arkose and carcareous siltstone.

Age - Lower Cretaceous, possibly Barremian

LILLOOET FORMATION

Slide 46-00 #45 Section H (uppermost)

Locality

West bank of Fraser River, one hald mile north of Bridge River.

Field Notes

Is overlain by tuffaceous arkose (Slide #44).

Interbedded with argillaceous rock.

Megascopic Description

Texture --- angular, fragmental material;
fragments average 0.2 to 0.5 mm.
(measured) in diameter.

Composition (Estimated)

Detrital	Authigenic
Orthoclase -- 30%	Pyrite
Plagioclase - 10%	Calcite
Quartz ------ 5%	

The plagioclase is indeterminate. The fragments cannot readily be distinguished from the groundmass (over 50% of the rock) which is felsitic, with considerable kaolinite?, partly devitrified glass and minor calcite.

Remarks

A large percentage of the rock is composed of fragments of lava, showing flow structure, and partly devitrified volcanic glass. These volcanic fragments blend into the groundmass. The feldspars are considerably altered to sericite.

Classification

Arkosic tuff

Age -- Lower Cretaceous, possibly Barremian

LILLOOET FORMATION

Slide 46-00 #44 Section H (Uppermost)

Locality

West bank of Fraser River, one half mile north of Bridge River.

Field Notes

Overlain by a gritstone that grades upward into a pebble conglomerate. Underlain by interbedded arkosic and argillaceous tuffs (Slide #45).

Megascopic Description

Bluish green arkose, weathering brownish.

Microscopic Description

Texture --- fragmental, angular material; fragments average 0.2 to 0.5 mm. (measured) in diameter.

Composition (Estimated)

Detrital
- Plagioclase - 35%
- Orthoclase -- 20%
- Quartz ------ 5%
- Epidote

Authigenic
- Calcite -- 5%

The matrix is felsitic, with considerable kaolinite?, some calcite and minor chlorite, constituting app. 35% of the rock. The plagioclase is of varying composition.

Remarks

About 50% of the rock is composed of fragments of volcanic feldspar porphyry showing trachytic structure. The groundmass is also largely of very small particles of this porphyry. Plagioclase was determined by refringence and statistical measurements on extinction angles in the zone at right angle to 010.

Classification

Tuffaceous greywacke

Age - Lower Cretaceous, possibly Barremian

FOUNTAIN RIDGE FORMATION

Slide 46-00 #42 Section G

Locality

North end of Fountain Ridge, on east side.

Field Notes

Massive bed, containing lenses of conglomerate from 1 to 4 feet thick. The conglomerate pebbles are of diorite, cherty quartzite, and siltstone. The bed is underlain by interbedded siltstone and argillite.

Megascopic Description

Indurated, greenish-grey arkose, weathering brownish-grey

Microscopic Description

Texture ------- Poorly sorted, angular, fragmental material; fragments average from 0.5 to 1.0 mm. in diameter (measured)

Composition (estimated)

Detrital		Authigenic
Orthoclase	10%	Calcite
Quartz	10%	Pyrite
Plagioclase	30%	
Hornblende		
Epidote		

The matrix, app. 50% of the rock, is felsitic, with minor chlorite, kaolinite, and calcite. The plagioclase is in part albite and/or oligoclase, as determined by refringence.

Remarks

The rock is composed of fragments of quartz, feldspar, carbonaceous argillite, and quartzite. Some plagioclase grains are relatively unaltered, while others have been considerably epidotized and seriticitized. A few apatite? inclusions were noted in the plagioclase. Some orthoclase shows a myrmekitic intergrowth with quartz.

Classification

Arkose

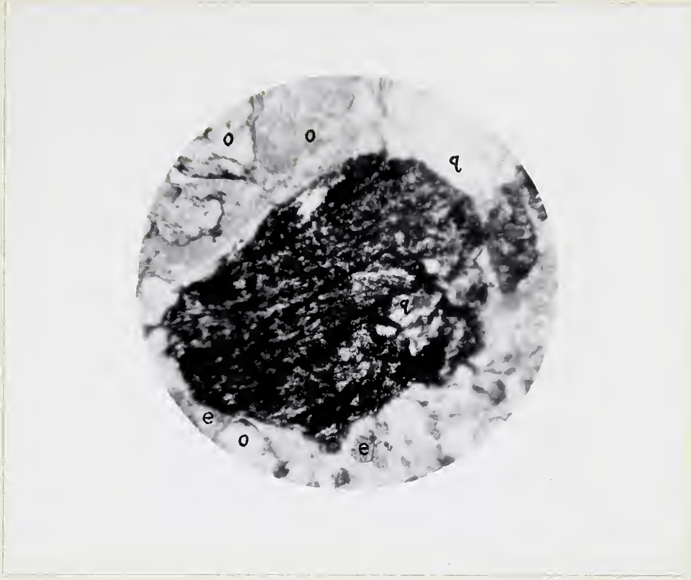
A - Slide 46-00 #42 Arkose

Using Burton lamp with white ground glass screen.
Super XX film. Exp. 4 sec. Plain light. Mag.X5
Fragment of argillite.
o ---- orthoclase
q ---- quartz
e ---- epidote

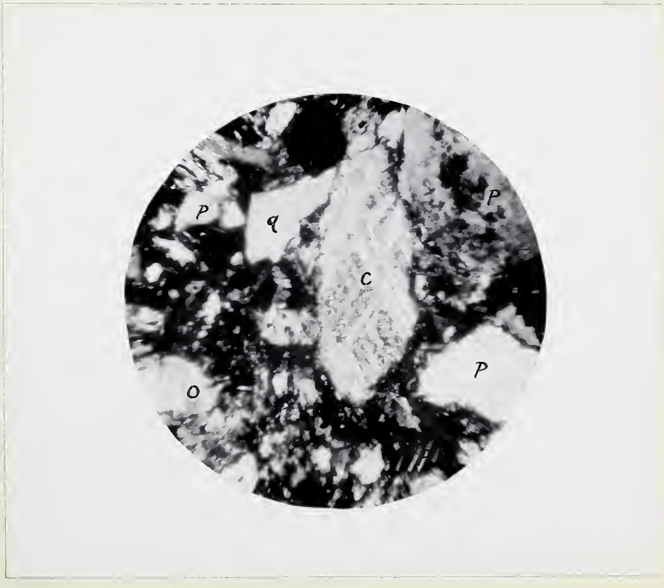
B - Slide 46-00 #42 Arkose

Using Burton lamp with white ground glass screen.
Super XX film. Exp. 9 sec. X nicols. Mag.X40.
Twinned calcite, a detrital fragment.
o ---- orthoclase
q ---- quartz
p ---- plagioclase (indeterminate)
c ---- calcite

PLATE 22



A - Slide 46-00 #42



B - Slide 46-00 #42

FOUNTAIN RIDGE FORMATION

Slide 46-00 #33 Section G

Locality

West flank of Fountain Ridge, two miles east of Lillooet.

Field Notes

Specimen is from a bed of sandstone containing a lens of conglomerate 4 feet wide. The pebbles in this conglomerate have an average diameter of 2 inches and are mainly of igneous rock, quartzite and argillite.

Megascopic Description

Greenish-grey sandstone, weathering brownish

Microscopic Description

Texture ----- poorly sorted, angular, fragmental material; fragments average from 0.2 to 0.5 mm. in diameter (measured).

Composition (estimated)

Detrital		Authigenic
Quartz	30%	Epidote
Plagioclase	5%	Calcite
Oligoclase	15%	
Biotite		

Remarks

Several fragments of plagioclase were found to be not more sodic than Ab90An10 (from measurements on extinction angles in the zone at right angle to 010). The plagioclase is fairly fresh in appearance, though some has in part altered to epidote. As some epidote fills interstices between the grains, it is considered to be authigenic. The quartz grains show dust rims. Calcite fills fractures in the rock. The rock is composed mainly of fragments of quartz, feldspar, and minor argillite.

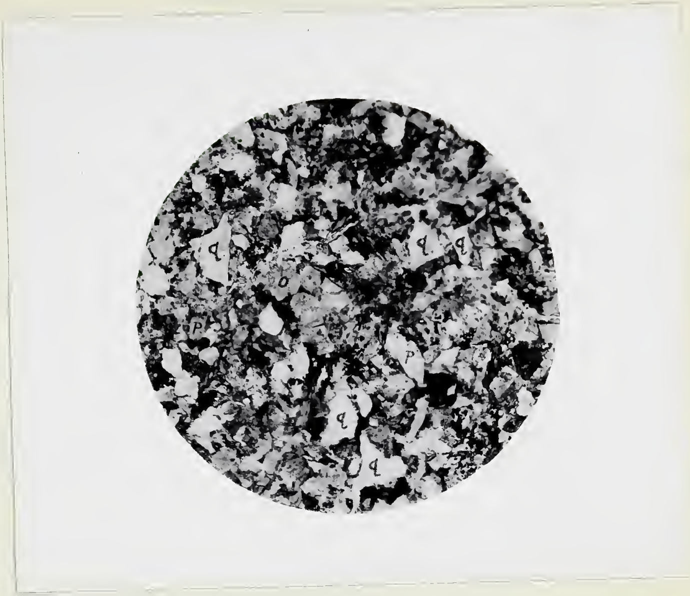
Classification

Arkosic sandstone

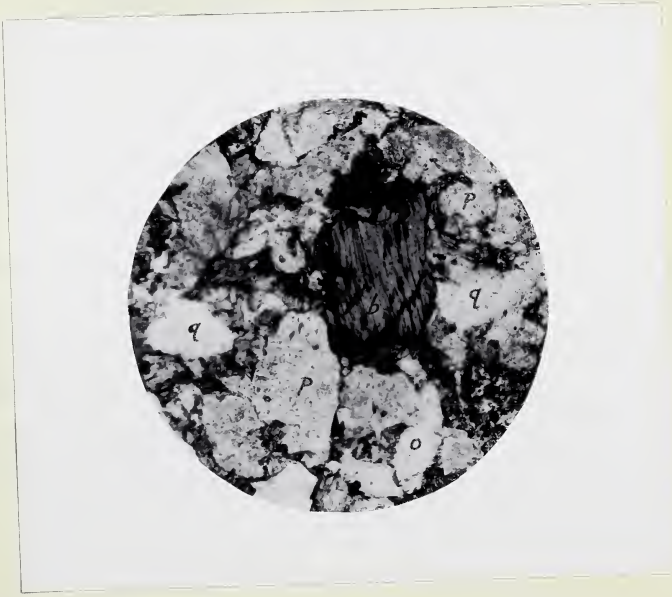
A - Slide 46-00 #33   Arkosic sandstone
Using Burton lamp with white ground glass screen.
Ansco Supreme film. G(Wratten) filter. Exp.6 sec.
Plain light. Mag. X20.
Angular, fragmental texture.
q ---- quartz
o ---- orthoclase
p ---- plagioclase (indeterminate)

B - Slide 46-00 #33   Arkosic sandstone
Using Burton lamp with white ground glass screen.
Ansco Supreme film. G(Wratten) filter. Exp. 5 sec.
Plain light. Mag.X60.
Biotite flake.
b ---- biotite
q ---- quartz
p ---- plagioclase (indeterminate)
o ---- orthoclase

PLATE 23



A - Slide 46-00 #33



B - Slide 46-00 #33

FOUNTAIN RIDGE FORMATION

Slide 46-00 #53

Section G
(upper)

Locality

North bank of Fraser River at north end of Fountain Ridge.

Field Notes

Specimen from a bed of arkose in the upper part of the conglomerate zone.

Megascopic Description

Dark grey arkose, weathering brownish-grey.

Microscopic Description

Texture ----- angular, fragmental material, the grains having been fairly well sorted as to size, and being on the average less than 0.2 mm. in diameter (measured).

Composition (estimated)

Detrital		Authigenic
Orthoclase	10%	Calcite
Plagioclase	20%	
Quartz	10%	
Biotite		
Epidote		

The matrix, consisting of app. 60% of the rock is felsitic, with kaolinite and minor chlorite (possibly from the alteration of biotite). The plagioclase is of varying composition.

Remarks

The rock is composed of fragments of feldspar, quartz, argillite, and a volcanic rock showing trachytic structure. The plagioclase shows some alteration to epidote, and the orthoclase to sericite.

Classification

Arkose

FOUNTAIN RIDGE FORMATION

Slide 46-00 #29 Section F (middle)

Locality

West side of Fountain Ridge, five miles south-east of Lillooet.

Field Notes

Underlain by banded siltstone and arenaceous rock.

Megascopic Description

Texture ------ fragmental, the grains averaging 0.2 to 0.5 mm. (measured) in diameter.

Composition (estimated)		Authigenic
Detrital		Calcite ?
Quartz	50%	Pyrtie
Orthoclase		
Oligoclase		
and/or Albite	15%	
Epidote	10%	
Biotite		

The groundmass, app. 25% of the rock, is of cryptocrystalline, felsitic material with minor chlorite.

Remarks

An indistinct orientation of the grains, probably indicates bedding. There are a few fragments of argillaceous rock. Quartz and orthoclase are not differentiated in the estimate of the percentage composition of the rock. The plagioclase is determined on the basis of extinction angles and refringence. Minor calcite probably is authigenic.

Classification

Arkose

Age

Lower Cretaceous, possibly Barremian.

FOUNTAIN RIDGE FORMATION

Slide 46-00 #50 Section F (upper)

Locality

West edge of Ashcroft Sheet, north of Bridge River.

Field Notes

A massive bed, stratigraphically below rock specimen #51.

Megascopic Description

Fine grained, fragmental, bluish-grey rock, weathering brownish-grey.

Microscopic Description

Texture ----- fragmental, the grains averaging 0.2 mm. (measured) in diameter.

Composition

The rock is composed largely of fragments of volcanic rock, some showing trachitic flow structure, and some showing a glassy flow structure. Groundmass is of cryptocrystalline felsitic and vitric material, and cannot readily be distinguished from the fragments. Some calcite and pyrite, probably authigenic, are present.

Remarks

In general the rock is very similar to Slide 46-00 #51. The rock has been considerably altered, the glassy material being mostly devitrified. The fragments of volcanic rock have brownish grey rims of an alteration product which may be of limonite stained felsitic material or of palagonite.

Classification

Tuffaceous greywacke.

Age

Lower Cretaceous, possibly Barremian.

FOUNTAIN RIDGE FORMATION

Slide 46-00 #38 Section E (lower)

Locality

West side of Fountain Ridge, one and a half miles north-east of Lillooet bridge across the Fraser River.

Field Notes

Interbedded with siltstone and bluish arkose.

Megascopic Description

Bluish grey, limy, argillaceous rock, weathering brownish grey.

Microscopic Description

Texture ----- fine grained, homogeneous rock; angular fragments averaging 0.05 mm. (measured) in diameter.

Composition

Microcrystalline and cryptocrystalline felsitic rock with considerable vitric material. Some shards of partly devitrified volcanic glass are visible. Much calcite, probably primary, is present. There is some pyrite, which is probably authigenic.

Remarks

The rock seems to have been a limy mud in which much volcanic ash has been deposited.

Classification

Argillaceous tuff

Age

Lower Cretaceous, possibly Aptian.

FOUNTAIN RIDGE FORMATION

Slide 46-00 #34 Section E (upper)

Locality

West side of Fountain Ridge, two miles east of Lillooet.

Field Notes

Massive bed, having some interbedded argillite bands, a few inches in thickness. Plant remains and fossils are in this horizon.

Megascopic Description

Greenish grey arenaceous rock, weathering brownish grey.

Microscopic Description

Texture ----- fragmental, the grains averaging 0.2 to 0.5 mm. (measured) in diameter

Composition

The rock is mainly composed of angular fragments of volcanic rocks, including trachitic and glassy types. There are also fragments of indeterminate plagioclase, orthoclase and quartz, argillite, epidote, biotite, and what are probably fragments of gneiss consisting of quartz and hornblende. Pyrite and calcite, probably authigenic, are present.

The groundmass is felsitic, with minor chlorite, and possibly some kaolinite.

Remarks

The angular fragments are very poorly sorted as to size. Some grains of quartz have inclusions, probably of apatite. The epidote is largely fragmental, and replaces feldspar.

Classification

Greywacke

Age

Lower Cretaceous, possibly Aptian.

FOUNTAIN RIDGE FORMATION

Slide 46-00 #51 Section D (lower)

Locality

West slope of ridge, 5 miles north west of the confluence of Bridge and Fraser Rivers.

Field Notes

A massive, fossiliferous bed (see fossil locality F12).

Megascopic Description

Greenish grey, fine grained rock, containing inclusions of fine grained blackish rock (of average diameter less than 0.25 inches). The rock weathers brownish.

Microscopic Description

Texture ----- fragmental, the grains averaging about 0.2 mm. (measured) in diameter.

Composition

The rock is composed mainly of fragments of volcanic rock, with very minor fragments of quartz. The intersitices between the grains are filled with felsitic and vitric material. Pyrite, and very minor calcite are probably authigenic.

Remarks

The grains are fairly well sorted as to size. Those of volcanic rock are rimmed with a dark brownish grey alteration product which may be palagonite, or felsitic material stained with limonite. Some spherulitic chalcedony is present in the interstices between grains.

Classification

Tuffaceous greywacke.

Age

Lower Cretaceous, probably Barremian or Aptian.

FOUNTAIN RIDGE FORMATION

Slide 46-00 #39

Section D
(middle)

Locality

North end of Fountain Ridge, on west side.

Field Notes

Overlain by a bed, some thirty feet thick, of conglomerate.

Megascopic Description

Greenish grey, arenaceous rock, weathering brownish.

Microscopic Description

Texture ----- fragmental, the grains averaging 0.5 mm. (measured) in diameter.

Composition (estimated)

Detrital		Authigenic
Orthoclase	40%	Pyrite
Quartz		
Plagioclase	10%	
Epidote	5%	
Calcite		

The groundmass, app. 45% of the rock, is felsitic, with minor chlorite, and possibly some kaolinite. The plagioclase is of varying composition.

Remarks

This rock is similar to Slide 46-00 #34. There are several fragments of volcahic rock showing trachitic structure, and some of argillite.

Classification

Arkosic greywacke.

Age

Lower Cretaceous, possibly Aptian.

LOWER CRETACEOUS INTRUSIVE

Slide 46-00 #30 Intrudes Section H

Locality

Base of Fountain Ridge, on west side, 8 miles south of Lillooet.

Field Notes

A sill, intruding calcareous siltstone and arkose of the Lillooet Formation.

Megascopic Description

Blackish, diabasic rock, with abundant hornblende.

Microscopic Description

Texture --- poikilitic, crystals of plagioclase and hornblende varying in length from 0.5 to 2.0 mm. (measured).

Composition (estimated)

Hornblend --- 50%
Albite ------ 25%
Quartz ------ 15%
Calcite ----- 5%
Antigorite?
Chlorite
Zoisite?
Titanite 5%
Apatite
Magnetite

Remarks

There are patches of a micrographic intergrowth of albite and quartz? The hornblende is probably secondary as it forms a poikilitic intergrowth in the plagioclase. Optically, the hornblende is pale olive green, has distinct pleochroism, a birefringence of app. 0.015, is biaxial and optically negative.

The plagioclase is biaxial, optically positive, with low birefringence, and a refringence less than 1.54. The 2V is greater than 60 degrees. Measurement of Z on 001 is 13 degrees. This albite is probably secondary.

Calcite fills fractures and interstices in the rock. The antigorite is platy to fibrous, colorless, with a birefringence slightly greater than that of quartz, and a refringence of app. 1.60. Chlorite and antigorite are probably secondary, after hornblende. A mineral, showing a 'Berlin' blue, abnormal interference color may be zoisite. Titanite is in part altered to leucoxene. Some magnetite is associated with the hornblende, and may have formed during the formation of the hornblende.

The rock in general appears to have been highly altered by deuteric action any by albitization.

Classification

Hornblende dolerite (altered)

Age

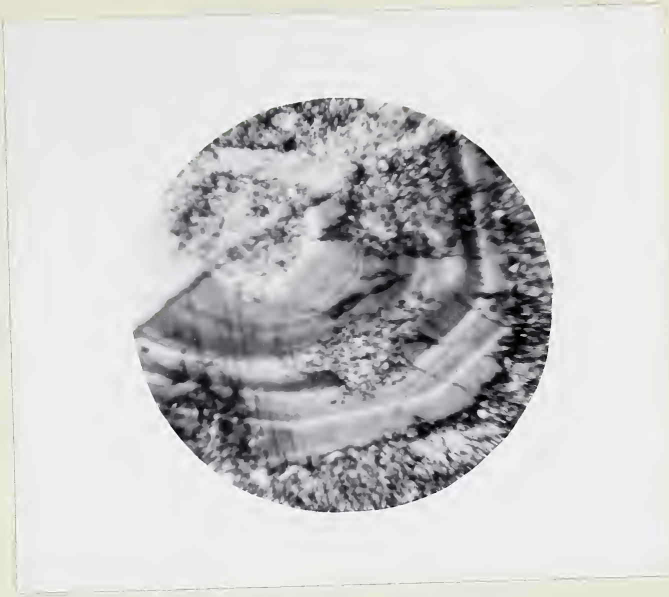
Probably Lower Cretaceous.

Slide 46-00 #37 Feldspar porphyry

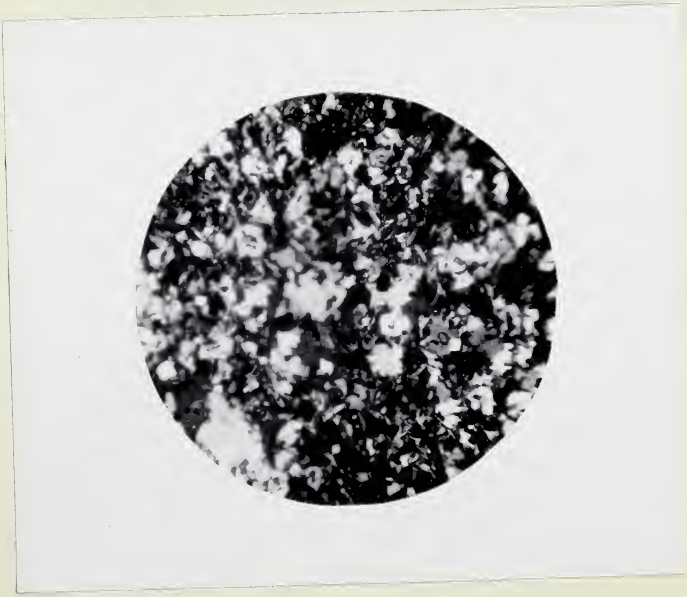
Using Burton lamp with white ground glass screen. Super XX film. X nicols. Exp. 10 sec. Mag. X35. Zoned phenocryst of labradorite, showing sericitic alteration of interior.

Slide 46-00 #40 Felsitic rhyolite

Using Burton lamp with white ground glass screen. Super XX film. Exp. 9 sec. X nicols. Mag. X80. Note the sutured structure of orthoclase and quartz grains.



Slide 46-00 #37



Slide 46-00 #40

LOWER CRETACEOUS INTRUSIVE

Slide 46-00 #37 Intruding Sections H, I

Locality

Three miles north-east of Lillooet.

Field Notes

Intrudes, as dykes and sills, the Lillooet Formation.

Megascopic Description

Light grey, feldspar porphyry.

Microscopic Description

Texture --- porphyritic, the phenocrysts averaging 2.0 to 3.0 mm. (measured) in diameter, the other grains measuring on the average app. 0.2 mm. in diameter.

Composition

The rock is felsitic, with phenocrysts of zoned plagioclase (indeterminate), and very minor quartz. Titanite, and large grains of apatite are present. Very minor chlorite, and some epidote (probably from the alteration of feldspar) are present. There is some pyrite.

The quartz, in part, is secondary. The most striking feature of this rock is the large amount of calcite (app. 20% of the rock) which seems to have in part replaced, in an intimate mixture with felsitic material, the feldspar phenocrysts.

In general, the rock is highly altered, and probably is of syenite composition.

Classification

Feldspar porphyry (altered)

Age

Probably Lower Cretaceous

A - Slide 46-00 #30   Hornblende dolerite

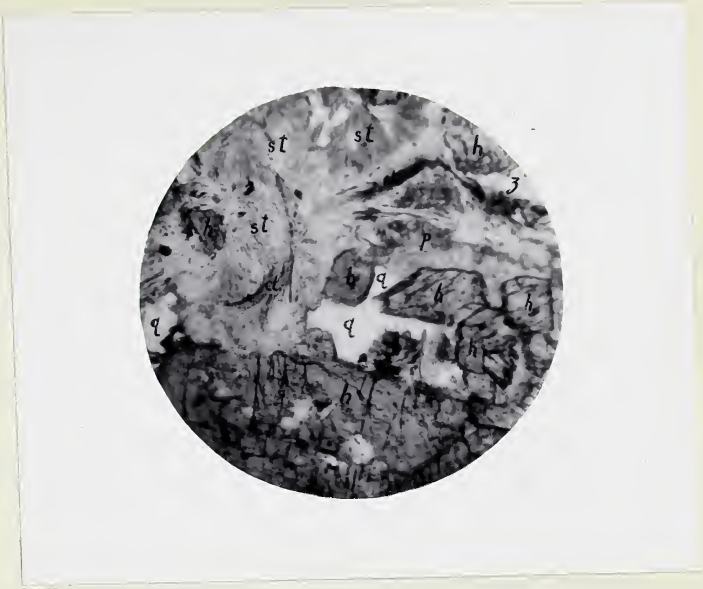
Using Burton lamp with white ground glass screen.
Super XX film. Exp. 4 sec. Plain light. Mag. X30.

st ---- serpentine (antigorite?)
h ----- hornblende
q ----- quartz
cl ---- chlorite
z ----- zoisite?

B - Slide 46-00 #30

ditto -------- X nicols. Exp. 12 sec.

PLATE 25



A - Slide 46-00 #30

B - Slide 46-00 #30

LOWER CRETACEOUS VOLCANICS

Slide 46-00 #25

Locality

Two miles north-east of the mouth of Fountain Creek.

Field Notes

Stratigraphically close to Specimen #26. Occurs as a bed, somewhat smashed, as it is in a shear zone.

Megascopic Description

Very fine grained, olive green rock.

Microscopic Description

Texture --- fragmental, very fine grained.

Composition

The rock is composed of scattered fragments of volcanic glass, volcanic rocks, and fragments of calcic plagioclase in a felsitic and vitric groundmass.

Remarks

Under high power the groundmass is seen to be composed largely of minute fragments of volcanic glass, probably originally having been an ash. Measurements of maximum extinction angles (in the zone at right angle to 010) indicate a composition at least as calcic as Ab40An60 for some fragments of plagioclase; and it is probable that all the plagioclase fragments are of labradorite.

Classification

Tuff

Age

Probably Lower Cretaceous

A - Slide 46-00 #25 Tuff

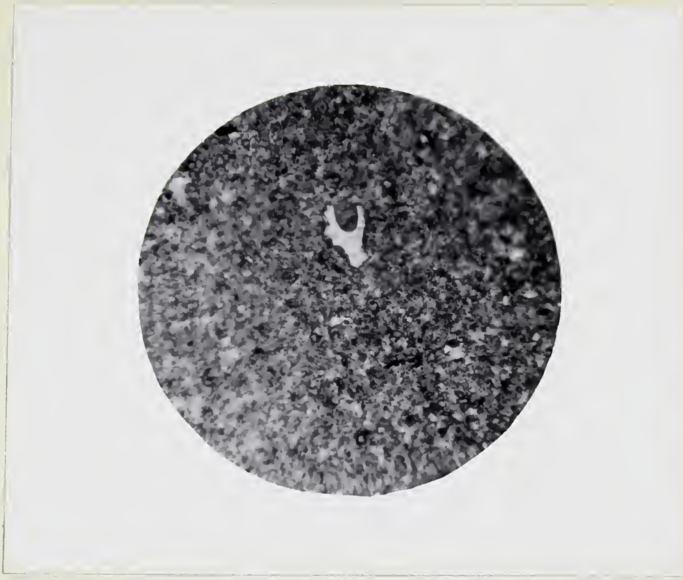
Using Burton lamp with white ground glass screen. Super XX film. Exp. 6 sec. Plain light. Mag. X40. Shard of volcanic glass in a vitric and chloritic groundmass.

B - Slide 46-00 #25 Tuff

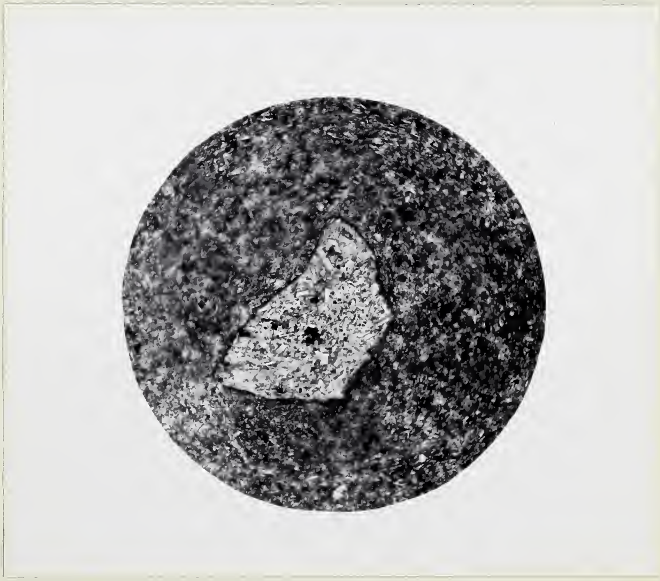
Using Burton lamp with white ground glass screen. Ansco Supreme film. G(Wratten) filter. Exp. 9 sec. Plain light. Mag. X35.

Fragment of felsite in tuffaceous and chloritic groundmass.

PLATE 26



A - Slide 46-00 #25



B - Slide 46-00 #25

LOWER CRETACEOUS VOLCANICS

Slide 46-00 #26

Locality

Two miles north-east of the mouth of Fountain Creek.

Field Notes

Stratigraphically close to Specimen #25. Occurs as a bed, somewhat smashed, as it is in a shear zone.

Megascopic Description

Bright green, arenaceous rock.

Microscopic Description

Texture --- fragmental, the fragments averaging 0.2 mm. (measured) in diameter.

Composition

The rock is composed wholly of fragments of volcanic rocks, with much glassy material, partly devitrified. Some fragments show trachitic structure, with a dendritic growth of magnetite. The groundmass is felsitic, being highly altered to chlorite, and was probably derived from volcanic ash. Plagioclase fragments (of varying composition) are comparatively unaltered. The rock thus appears to show differential alteration, the groundmass apparently having been more basic, and therefore more readily altered. Some plagioclase crystals are zoned. Pyrite and limonite are present in minor amounts.

Classification

Tuff

Age

Probably Lower Cretaceous

LOWER CRETACEOUS VOLCANICS

Slide 46-00 #40

Locality

One and a half miles north east of the mouth of Fountain Creek, on the east bank of Fraser River.

Field Notes

A flow rock, distinctly brecciated, near the faulted contact with the Lower Cretaceous sediments.

Megascopic Description

A light grey, homogeneous rock, giving the characteristic kaolin odor. Intersitices in the breccia are filled with a zeolite.

Microscopic Description

Texture ----- very fine grained, sutured structure
Composition
    Orthoclase
    Plagioclase (very minor)
    Quartz (minor)

The grain size is too small to estimate percentage composition. The feldspar is partly kaolinized. Some pyrite and limonite is present. Crushed mounts show very fine needles of a zeolite, possibly natrolite?

Classification

Felsitic rhyolite

Age

Probably Lower Cretaceous

LOWER CRETACEOUS VOLCANICS

Slide 46-00 #52

Locality

South bank of Red Creek, one mile west of Fraser River.

Field Notes

A volcanic flow, underlying the flow from which Specimen #54 was taken. The beds are folded and sheared, and are close to the faulted contact with the Lower Cretaceous sedimentary rocks.

Megascopic Description

A dark, grey feldspar porphyry.

Microscopic Description

Texture --- basaltic, with trachitic and porphyritic structure

Composition

- Labradorite
- Augite (minor) --- less than 10%
- Chlorite (very minor)
- Magnetite (minor)
- Hematite (minor) - less than 5%
- Calcite (very minor)

Remarks

The rock is, in general, microcrystalline to cryptocrystalline, with lath shaped crystallites of indeterminate plagioclase forming a trachitic structure in the felsitic groundmass. Some phenocrysts of labradorite have a zoned structure. These phenocrysts have undergone sericitization. Less than 10% of the rock is of augite, which has in part altered to chlorite. Magnetite appears to be primary, forming less than 5% of the rock. Secondary hematite fills fractures in the rock and cleavage cracks in the plagioclase phenocrysts. Some calcite fills pores in the rock.

Classification

Porp hyritic basalt

Age

Probably Lower Cretaceous

LOWER CRETACEOUS VOLCANICS

Slide 46-00 #54

Locality

On Red Creek, one mile from Fraser River.

Field Notes

A volcanic flow rock, folded and somewhat sheared, in the proximity of a faulted contact with Lower Cretaceous sedimentary rocks.

Megascopic Description

Dark grey, fine grained, homogeneous rock, showing flow bands. Fractures filled with hematite. Weathers reddish.

Microscopic Description

Texture ----- basaltic, with trachitic flow structure.

Composition (estimated)

Labradorite	85%
Olivine Hornblende	10%
Magnetite	5%

Minor chlorite, from the alteration of hornblende, is present. Fractures are filled with hematite and calcite. The plagioclase is not more sodic than Ab55An45, as determined from measurements of extinction angles in the zone at right angle to 010.

Remarks

The hornblende has probably formed after pyroxene. The optical characteristics of this hornblende are as follows:
Color - yellowish green; not markedly pleochroic; very low refringence; birefringence app. 0.15 to 0.20; nearly parallel extinction; sign of elongation is positive; optically negative; $2V$ is less than 60 degrees as measured on a section parallel to 100; basal cleavage or parting; stout, prismatic crystals.

Classification

Trachitic basalt

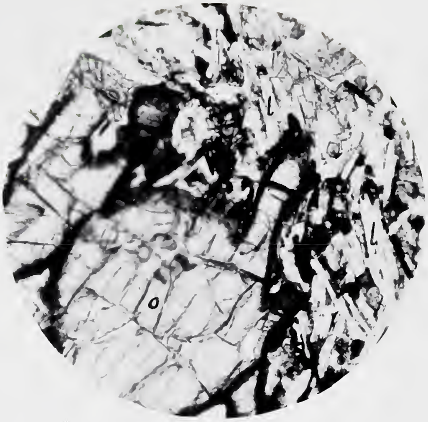
Age

Probably Lower Cretaceous

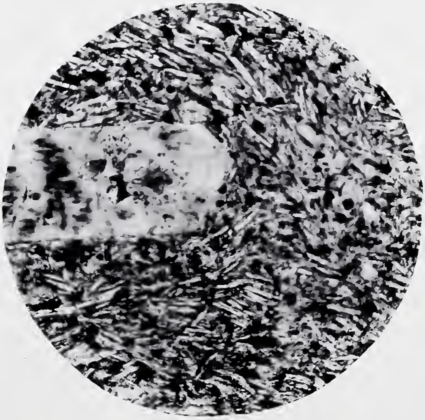
Slide 46-00 #55 Vescicular olivine basalt.
Using Burton lamp with white ground glass screen.
Ansco Supreme film. G(Wratten) filter. Exp. 6 sec.
Plain light. Mag. X45.
o ---- olivine, showing dark rim of alteration product, probably limonite
l ---- labradorite laths

Slide 46-00 #54 Basalt
Using Burton lamp with white ground glass screen.
Ansco Supreme film. G(Wratten) filter. Exp. 4 sec.
Plain light. Mag. X35.
Trachytic structure of labradorite laths flowing around a crystal of hornblende. Dark spots are crystals of magnetite.

PLATE 27



Slide 46-00 #55



Slide 46-00 #54

LOWER CRETACEOUS VOLCANICS

Slide 46-00 #55

Locality

North-west corner of the Ashcroft Sheet.

Field Notes

Specimen taken from the bottom of a flat lying volcanic flow, 8 feet thick, which was underlain by another flow of approximately the same thickness. The upper part of each flow was vescicular.

Megascopic Description

Grey, vescicular diabase.

Microscopic Description

Texture ---ophitic, the plagioclase laths measuring on the average 0.2 mm. in length.

Composition (estimated)
Labradorite --- 50%
Augite -------- 30%
Olivine ------- 10%
Magnetite
Hematite ------ 10%

Remarks

Measurements on several plagioclase laths gave a maximum extinction angle (in the zone at right angle to 010) of 38 degrees, indicating that the p-lagioclase is not less calcic than Ab35An65. Magnetite may have formed after olivine. The magnetite has been considerably altered to hematite. The olivine grains are rimmed with limonite, and/or hisingerite?

Classification

Diabasic olivine basalt

Age

Probably Tertiary (Oligocene?)

PERMIAN VOLCANICS

Slide 46-00 #57 Chilliwack Group

Locality

Three miles south of Lillooet.

Field Notes

Specimen taken from a massive and sheared bed near the faulted contact between the Chilliwack Group and the Lillooet Formation. This bed is intruded by koalinized leucocratic dykes.

Megascopic Description

Dark green, serpentinized rock.

Microscopic Description

Texture --- a felt of antigorite surrounding angular fragments of serpophite.

Composition (estimated)

Antigorite ---- 85%
Serpophite ---- 10%
Magnetite ----- 5% or less

Remarks

The serpophite (in part serpentine) is isotropic, colorless. Magnetite occurs as a network and is probably secondary. For illustrations of a section almost identical with this, see Roger and Kerr, "Optical Mineralogy", p.362.

Classification

Serpentinized (basic volcanic?)

Age

Probably Permian.

GLOSSARY OF TERMS

Argillaceous tuff --- a fine grained, dark grey rock consisting essentially of volcanic ash (glass) with minor amounts of argillaceous matter.

Arkose -- a grey, arenaceous rock, composed largely of fragments of feldspar, with minor fragments of quartz, and very minor fragments of argillite and volcanic rocks (derived from the erosion of volcanic beds).

Arkosic tuff --- a grey, arenaceous rock, consisting essentially of volcanic ash (glass) and fragments of feldspar. i.e. a crystal-lithic-vitric tuff (see Pirsson (1915))

Greywacke --- a grey, arenaceous rock, composed largely of fragments of basic volcanic rocks (derived from the erosion of volcanic beds), with minor fragments of feldspar, quartz, and argillite.

Greenstone --- a greenish rock, sometimes schistose and often serpentinized, presumably derived from the alteration of a basic volcanic of indeterminate origin.

Shard --- fragment of volcanic glass, occurring as sharp edged, conchoidal flakes, fibres, bubble walls, and cellular pumice forms. (See definitions as given by Grout "The Petrology of Igneous Rocks"

Tuff ---- a pyroclastic rock.
Lithic tuff -- composed of fragments of volcanic rocks
Crystal tuff - composed of crystals, some euhedral and corroded
Vitric tuff -- composed of shards and other fragments of volcanic glass
(See Pirsson (1915))

Tuffaceous sediment -- a sediment containing p-yroclastic material which has not been derived from the erosion of a volcanic bed.

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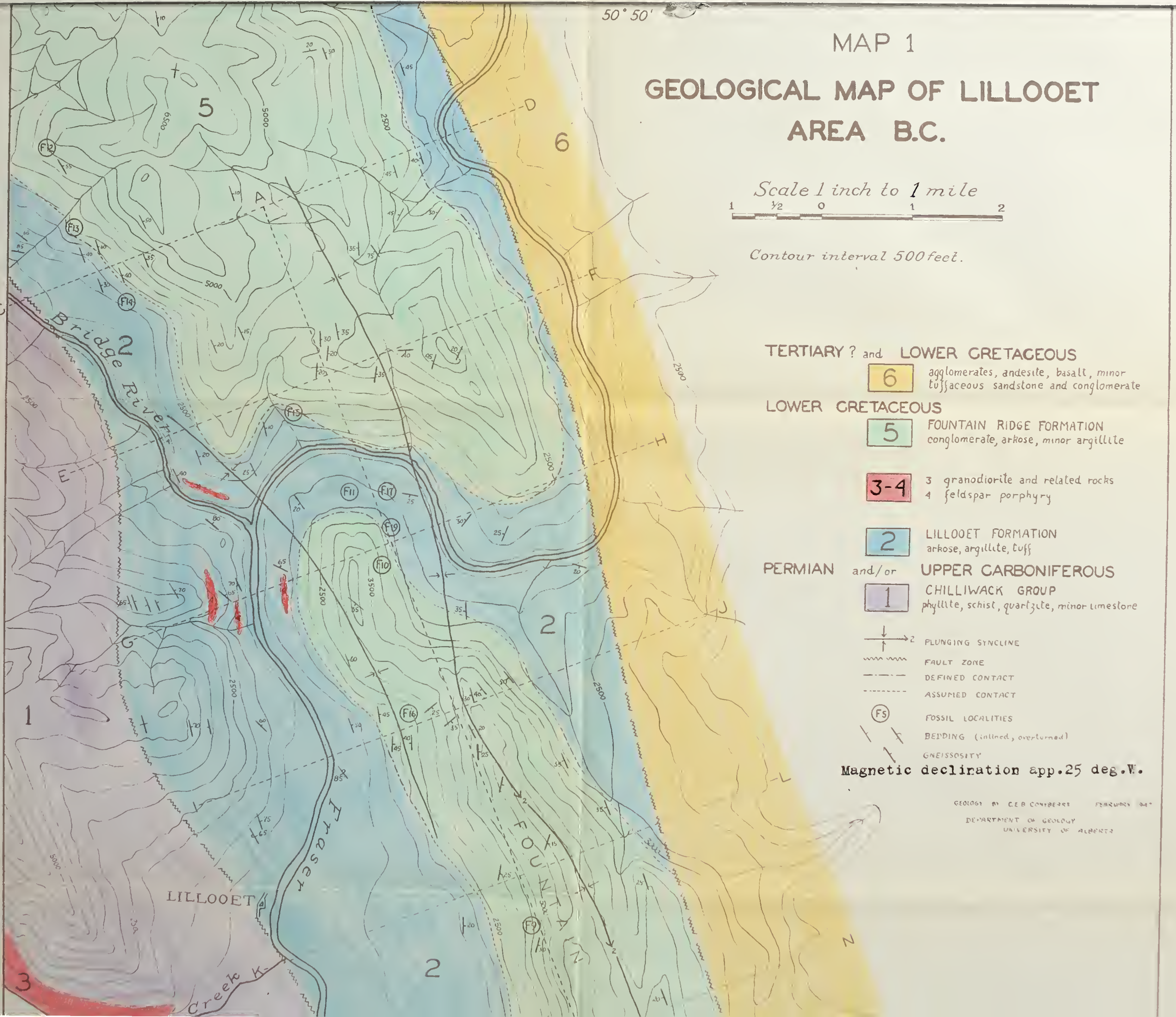
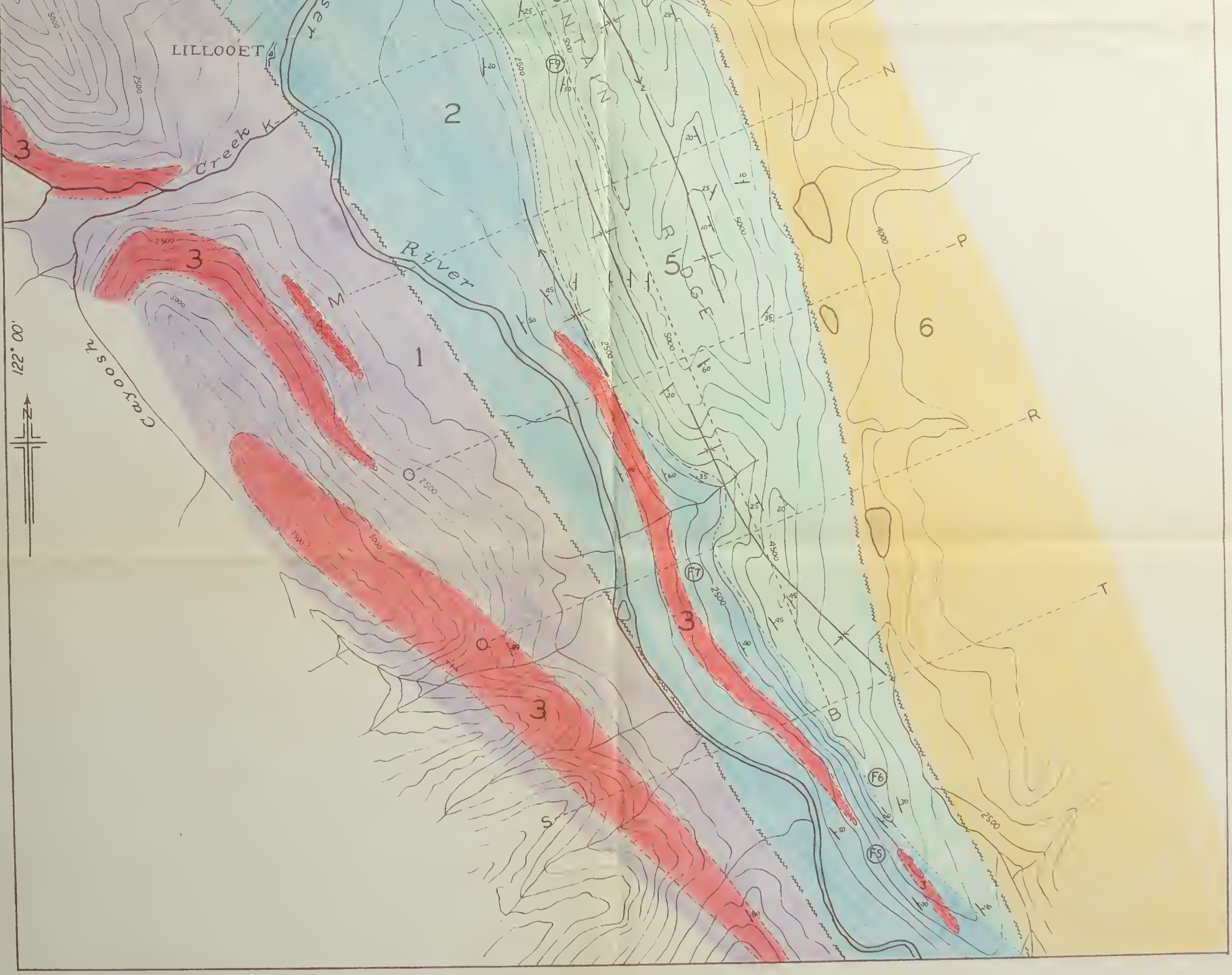
MAP 1

GEOLOGICAL MAP OF LILLOOET AREA B.C.


50° 50'
Scale 1 inch to 1 mile
1 ½ 0 1 2
Contour interval 500 feet.
TERTIARY ? and LOWER CRETACEOUS
6 agglomerates, andesite, basalt, minor tuffaceous sandstone and conglomerate
LOWER CRETACEOUS
5 FOUNTAIN RIDGE FORMATION conglomerate, arkose, minor argillite
3-4 3 granodiorite and related rocks 4 feldspar porphyry
2 LILLOOET FORMATION arkose, argillite, tuff
PERMIAN and/or UPPER CARBONIFEROUS
1 CHILLIWACK GROUP phyllite, schist, quartzite, minor limestone
PLUNGING SYNCLINE
FAULT ZONE
DEFINED CONTACT
ASSUMED CONTACT
FS FOSSIL LOCALITIES
BEDDING (inclined, overturned)
GNEISSOSITY
Magnetic declination app.25 deg.W.
GEOLOGY BY C.E.B. CONYBEARE FEBRUARY
DEPARTMENT OF GEOLOGY UNIVERSITY OF ALBERTA
Bridge River
Fraser
FOUNTAIN
LILLOOET
Creek
A
C
D
E
F
G
H
J
K
L
N
F9
F10
F11
F12
F13
F14
F15
F16
F17
F19
1
2
3
5
6
2500
3500
5000
6500


LILLOOET
Creek
Cayoosh
River
122° 00'
N
RIDGE
1
2
3
5
6
M
N
O
P
Q
R
S
T
B
F9
F7
F6
F5
2500
5000
4500
4000

MAP 408 A, to accompany M.Sc. thesis by C.L.B. Conybeare (1947)

N.B. The Lower Cretaceous rocks (green, 3) are not differentiated as to formations, and therefore comprise the Lower Cretaceous (green, 5 and blue, 2) of MAP No. 1.

This legend is used by the Geological Survey of Canada.

CANADA
DEPARTMENT OF MINES AND RESOURCES
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MINES AND GEOLOGY BRANCH
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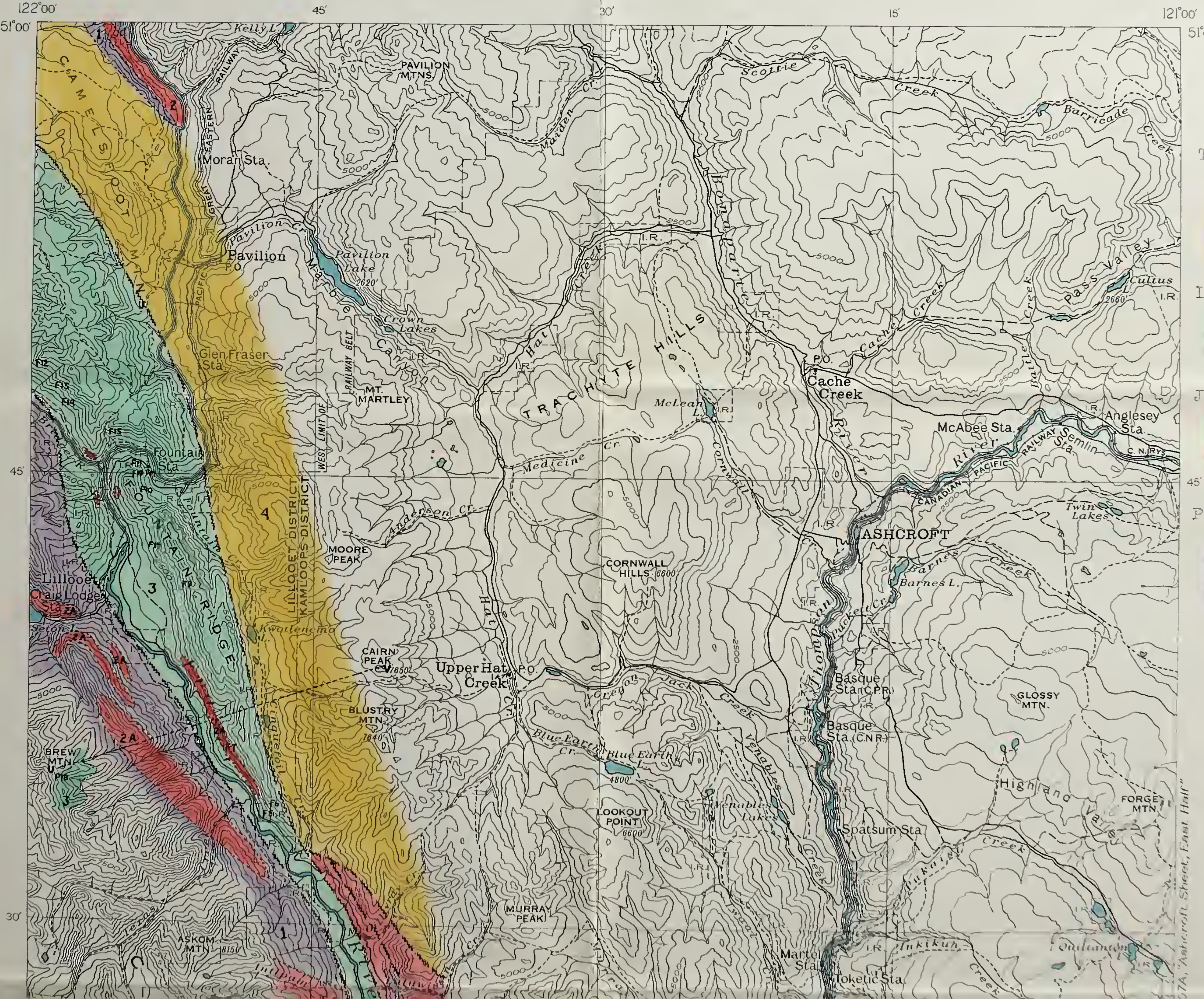
BUREAU OF GEOLOGY AND TOPOGRAPHY
F.C.C. LYNCH, CHIEF
ISSUED 1938



LEGEND

Tertiary? and Lower Cretaceous

4 volcanics

Lower Cretaceous

3 conglomerate
arkose
argillite

Jurassic and later

2 granodiorite
quartz-diorite

2A -Low. Cretaceous?

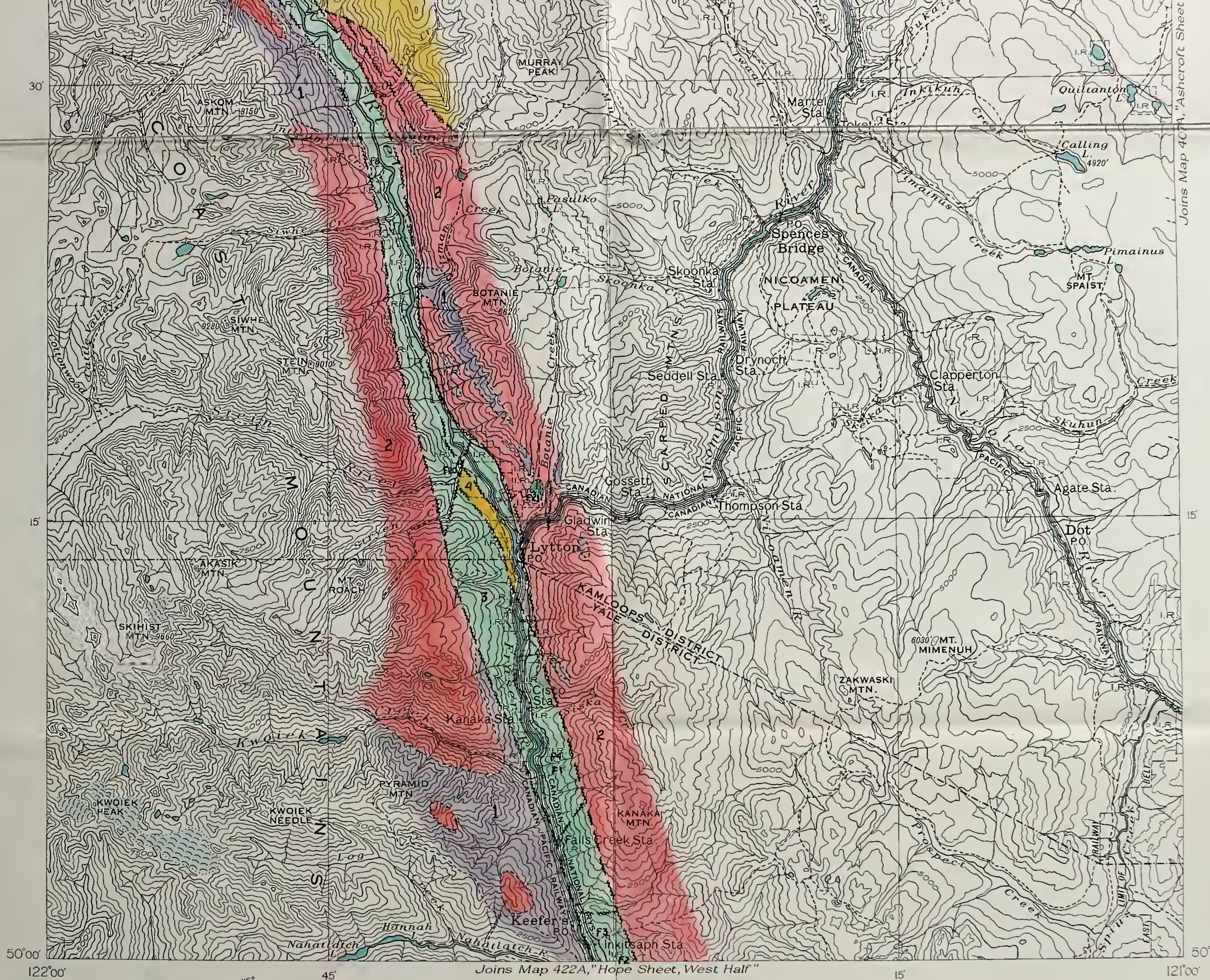
Permian and/or Upper Carboniferous?

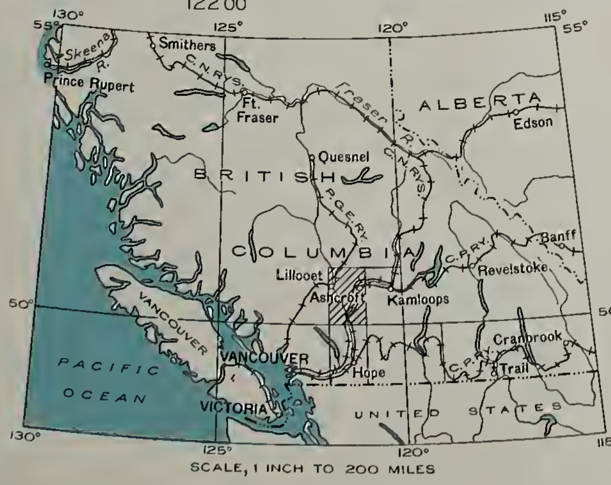
1 phyllite
schist
quartzite
crystalline-limestone

Shear zone

Assumed contact

F1-F21 Fossil localities





MAP 408A

ASHCROFT SHEET

(WEST HALF)

KAMLOOPS, LILLOOET, AND YALE DISTRICTS
BRITISH COLUMBIA

Scale, $\frac{1}{253,440}$ or 1 Inch to 4 Miles

Miles 4 0 4 8 12

Kilometres 5 0 5 10 15

Contour interval 500 Feet.
Approximate magnetic declination, 25° East.

LEGEND

Road	———
Road (not well travelled)	– – – –
Trail	- - - - -
Church	⁝
Post office	⁝
Land District boundary	—·—·—
Limit of Railway belt	— — —
Indian Reserve boundary	- - - - -
Intermittent stream	—··—
Glacier	▨
Contours	≋
Contours (position approximate)	≋
Height in feet	7335'

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